THE GLASS INDUSTRY
THE JOURNAL OF GLASS MANUFACTURING

Lava Glass

By Albert Christian Revi

On December 12th, 1878, an article entitled "Aetna and Its Lava Streams," appeared in the *Crockery & Glass Journal*. The story rather dramatically introduced a new kind of glassware made by the Mt. Washington Glass Company of New Bedford, Massachusetts.

The glass was composed primarily of volcanic lava. According to some accounts related in that journal, the variety of effects produced were very attractive and graded from a soft, velvety porphyry finish to a brilliant mosaic. It was difficult to decide which was the most beautiful.

"Sicilian Ware," as the new material was called, in view of the fact that its chief element was obtained from "the lava flows of Mt. Aetna" (in Sicily), was introduced in all the leading stores where it attracted considerable attention, some of the ornaments being "very grotesque and pleasing."

Prior to its introduction to the trade, Frederick S. Shirley, the agent for the New Bedford firm, patented two means for producing his lava glassware. The first patent, dated May 28th, 1878, covers a compound that was capable of being blown, pressed or otherwise fashioned. It consisted of seven parts of clear flint batch, one part carbonate of potash or its equivalent, and two parts of lava or volcanic slag. The slag, being mixed with vitreous impurities, combined with and colored the mass, producing many tints and colors which were varied according to the proportions of the above ingredients.

When the melted mass was in the proper condition for working, it was blown or otherwise molded into any shape desired. Shirley emphasized that this melt was especially adapted for making copies of antique urns and vases and copies of works of art.

If desired, regular glass, except clear flint and plain white or opal glass (which decolorizes the coloring mixture) could be used and colored with the necessary

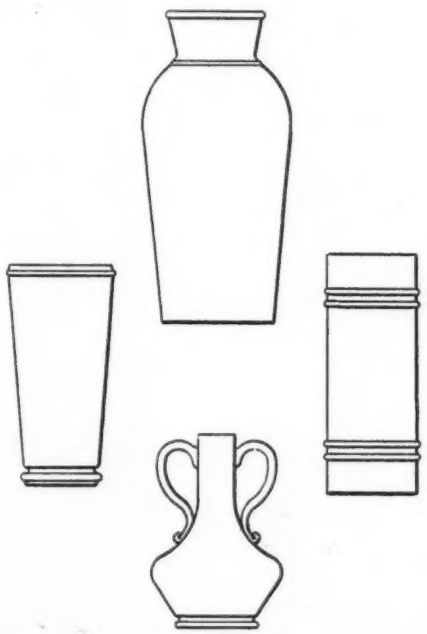

Fig. 1. Illustration from F. Shirley's patent for "An Improvement in Manufacture of Glass from Lava". May 28, 1878.

From the book, "Nineteenth Century Glass—Its Genesis and Development," by Mr. Revi, to be published in the Fall by Thomas Nelson & Sons, New York.

chemicals to produce the required and varied colors.

In this instance the glass was rendered opaque either by coating or backing with such dense coloring matter as vitrified cobalt, taffee, calcined vitriol, or their requisite equivalents for the several colors required. These substances were used as a substitute for the lava.

Shirley suggested in his patent specifications that the articles made from this lava glass melt could be left in their original glazed finish, or could be wholly or partially treated in an acid bath to give them a dull, lusterless appearance.

The second patent, acquired by Shirley on September 30, 1879, referred primarily to methods for decorating his Sicilian Ware. Preferring to use glass having lava mixed with it, so as to have a dark, perfectly black, or colored background, for making a stronger contrast, he imbedded into the surface of the article colored glass or other vitreous material.

The pieces inserted for the sake of decoration were usually analogous to the material out of which the article was made. If this were not possible, the pieces selected were backed with a coating of suitable fluxing, so that they would be absorbed more readily into the surface of the glass.

Colored beads of glass and pieces of metal were picked up from the marver by rolling the plastic parison over it; reheating and warming-in followed to amalgamate the article and its applied decoration.

Where irregular designs were desired, such as mosaic patterns, colored pieces or plates of glass or lava, usually opaque, were broken or cut into the required shapes. These were then imbedded into the surface of the glass article. By using a flux of a dense white, or a brillant color, and by having it flow around the edges of the inserted glass pieces, a fine finish was secured, especially effective on a black or dark-colored ground.

When grotesque figures or ornamentations were desired, the pieces to be inserted (of different colors, forms and sizes) were "floated" on the glass. After the articles were finished, an artist took his brush and added gilt or color, transforming them, through his imaginative touch, into figures of animals and human beings of the most grotesque forms.

Where metallic figures were added, gold traceries or designs were painted all around the article. When it was desired to form figures of these pieces, without outlining them in gold and adding parts of the figures to them, the pieces were cut through to the dark backing of glass by means of the etching process, copper engraving wheels, or other similar methods.

If special designs were required, the glass worker formed the pieces that were to be attached or inserted in special molds or formers. These pieces, in whatever form or color was preferred, were fluxed over and then applied to metal plates having indented lines or figures. A hot mass of glass was then worked over the figures, so as to attach them to the plate, thereby producing them in relief, or cameo, effect.

Perforated metal shells, or pieces of metal, could be attached to the glass article that was being formed while the glass was yet soft. The glass was then blown and finished. All the glass points projecting through the metal plates, or network, could be cut away and polished down to the metal surface, producing the same effects as shown in Japanese metal-enamel ware, called cloisonné.

In the late 19th century archeological explorations at Troy and Mycenae unearthed strange and wonderful forms of art that excited and influenced the public's taste in decorative glassware. Lava glass must have lent itself well to the grotesque forms and copies of ancient glass and pottery which were in vogue at that time. Articles in the Chinese taste were also manufactured, as indicated in the patent illustrations for September 30, 1879. This awareness of ancient art forms resembles somewhat the Greek Revival of a much earlier period.

While it appears to be in scant evidence, Sicilian Ware was most certainly manufactured and sold through the Mt. Washington Glass Company's New York City showrooms at 20 College Place; at that time it was under the direction of William H. Lum. In subsequent issues of the various trade journals Mr. Shirley advised the trade that his works were filling orders for the new glassware just as quickly as they could, which would indicate that it was a commercial success.

Frederick S. Shirley's Sicilian Ware had many prototypes. As early as 1771 the famous chemist le Sage discovered that one could bring black lava, as well as basalt, into fusion again.

Carolina Maria, the cruel and dissolute Queen of Naples (sister of the ill-fated Marie Antoinette of France) was probably the first to give instructions to her glass works to make glass out of lava in the manner

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Fig. 2. Illustration from F. Shirley's patent for decorating his lava glassware, September 30th, 1879.

William Chittenden Taylor

Corning Glass Works, and the world of science, have lost one of their most distinguished glass technology leaders.

Dr. William Chittenden Taylor, 72, honorary vice president and general technical advisor of Corning, died November 1, 1958, at his home in Corning, N. Y. On that same evening he had attended the company's annual service dinner; his unexpected death came as a shock to company officers, fellow associates and hundreds of friends throughout the nation.

Just four days previously, Dr. Taylor, together with Dr. Eugene C. Sullivan and Dr. Jesse T. Littleton, also of Corning Glass Works, had received the tribute of 85 fellow research scientists and engineers during an informal program commemorating the 50th anniversary of Corning's research laboratories.

At the testimonial dinner, Amory Houghton, chairman of the board of Corning Glass Works, now on leave as Ambassador to France, said of the three men, "The world is a much better place in which to live because of your contribution."

Dr. Taylor was co-inventor (with Dr. Eugene C. Sullivan) of heat and corrosion-resistant glass marketed under the Pyrex trademark. He was born in San Francisco, Calif., in 1886 and was graduated from Massachusetts Institute of Technology in 1908. He joined the new Corning laboratory as a chemist upon graduation in 1908, and in 1920 was appointed chief chemist. It was in 1912 that Dr. Taylor and Dr. Sullivan succeeded in their efforts to find a glass that was resistant to heat, temperature change and corrosion.

Dr. Taylor became director of glass technology for Corning Glass Works in 1939 and in 1943 was elected a vice president of Corning and, later the same year, director of the Manufacturing and Engineering Division. Up to 1939 he had done considerable work in batch testing and composition, and he directed several laboratory groups in research on glasses.

In 1947, he was appointed director of manufacturing and was elected an honorary vice president in 1954 and appointed general technical advisor. He also was a director of Corhart Refractories Company, a wholly-owned subsidiary.

Dr. Taylor, in his 50 years with Corning Glass Works, had seen glass technology undergo a complete revolution in methods. During the half century he had witnessed the change from intermittent melting of glass in pots to continuous melting in tanks, and the manufacture of

glassware from hand-and-blow methods to fast production by machines. The result was a breadth of acquaintance with glass manufacturing operations which few men have enjoyed; and consequently, he was invaluable as a consultant.

The holder of 33 patents, Dr. Taylor was co-patentee of the original glasses sold under Pyrex and Nonex trademarks. He also was active in the development of bulb glasses universally used in this country for incandescent electric lamps and radio tubes and many other purposes. In addition, he helped develop glasses for transmitting or absorbing specific spectral wave lengths in the visible, in the ultraviolet, and in the infrared.

His technological contributions had, of course, been outstanding and his quiet decisiveness of character had made him a force in the Corning organization.

Dr. Taylor was strongly influential in bridging the difficult gap between the experienced glassworker and the technical graduate, teaching on the one hand the trained man to profit from the veteran's years of observation, and on the other hand, getting the old timer to realize that the newcomer might be able to help him.

He was a man of gentle wit and humor. One of his associates recalls the time an inspection foreman lost a

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Fifth International Glass Congress

• THE FIFTH INTERNATIONAL CONGRESS on Glass is this year taking place in Munich, Germany from June 29 through July 4. This is the first technical and scientific congress on glass which has ever been held in Germany.

The primary purpose of the Congress is to bring together for discussions the leading experts on glass in the various fields of natural science, technology and arts, history and design. Accordingly, the program is divided in two parts: 45 technical and scientific papers and 17 lectures related to the history and design of glass.

The Fifth Congress was organized by the Deutsche Glastechnische Gesellschaft and the Bundesverband Glasindustrie in cooperation with the International Commission on Glass.

The International Commission was originally founded in 1933 during a Congress on Glass and Ceramics in Venice and Milan. The incentive was provided by Dr. H. Maurach, the late secretary of the Deutsche Glastechnische Gesellschaft, Professor J. A. de Artigas (Spain), Dr. John C. Hostetter (U.S.A.), B. Long (France), Professor A. Mauri (Italy), and Professor W. E. S. Turner (United Kingdom).

The Second International Congress was held in London and Sheffield in 1936, and the Third Congress, was scheduled for Berlin, Germany, in 1939 but had to be cancelled because of world conditions.

After World War II, Professor Turner reorganized the Commission which was re-founded at a general meeting in Buxton, England. New Statutes were drawn up to correspond with the revised post-war conditions.

The Third Congress was then held in Venice (1953); the Fourth, in Paris (1956); with the Fifth and current Congress scheduled for Munich this month.

Because of the importance of the International Glass Congress to glass technologists throughout the world, a complete list of the manuscript titles and their authors is presented below.

NATURAL SCIENCE AND TECHNOLOGY

Bound manuscripts of all technical papers in this group have been sent to each participant.

During presentation at the Congress, each lecturer will speak from 10 to 15 minutes and will give a summary of his individual paper. These papers will not be read in full at the Congress.

This arrangement has been made in order to provide ample time for a thorough discussion of the papers among the participants.

I CONTROL OF GLASS QUALITY.

1. **Some Views on Automatic Control in Glass Factories.** P. M. CUPIDO, N. V. Philips' Gloeilampenfabrieken, Eindoven (Netherlands).
2. **Application of Statistical Methods in the Manufacture of Sheet Glass.** E. PLUMAT, Union des Verreries Mecaniques Belges, Gilly (Belgium).
3. **Control of Mixing of Raw Materials according to the Statistical Calculus Applied to Chemical Analysis.** G. BORIN AND N. SICURELLA, "Vetrocoke" S.P.A., Porto Marghera (Italy).
4. **Methods of the Identification of Stones and Cords in Glass.** M. A. BESBORODOW, Minsk (Russia).
5. **Silicate Analysis with an automatic Recording Spectrograph.** F. HARTLEY AND W. WARK, Pilkington Brothers Ltd., St. Helena (Great Britain).
6. **Methods of the Spectral-Analysis, its Accuracy and its Application on Glass.** G. SHEIBE, Technische Hochschule, Munchen (Germany).
7. **The Application of Fluorescence to Problems of Glass Manufacturing.** J. LEBLANC, E. TAYLOR AND J. P. POOLE, Brockway Glass Company (U. S. A.)

II. INVESTIGATION OF GLASS MELTING AND FORMING PROCESSES.

8. **Study of Glass and Mold Temperature in Commercial Glass Container Forming Operations.** H. H. HOLSCHER, J. C. COLEMAN AND C. C. COOKE, Owens-Illinois Glass Co. (U. S. A.).
9. **Viscosity Distribution and Flow of Glass in Blank Molds.** W. TRIER, Huttentechnische Vereinigung der Deutschen Glasindustrie, Frankfurt (Germany).
10. **Air Cooling of Glass Molds.** R. WILLE, Technische Universitat, Berlin-Charlottenburg (Germany).
11. **Utilization of an Immersion Viscometer for the Practical Determination of Temperature in Molten Glass.** G. GEERAERT, Glaces et Verres S. A., Brussels (Belgium).
12. **Measurement of Radiation of Glass Using the Bolometer. Application to Measurement of Temperature.** E. PLUMAT, Union des Verreries Mecaniques Belges, Gilly (Belgium).
13. **Heat Balance of a Glass-Melting Furnace and its Recent Developments.** J. GAILHBAUD, Glaceries de la Cie. de Saint-Gobain, Paris (France).
14. **Some Economic Aspects of Furnace Instrumentation.** P. M. CUPIDO AND B. J. HOETINK, N. V. Philips' Gloeilampenfabrieken, Eindoven (Netherlands).
15. **Researches on Sodium Carbonate Hydration Phenomena Inside the Batch, with the Purpose of Avoiding Segregation of Constituents.** L. MALARME, Solvay & Cie., Brussels (Belgium).

III. MECHANICAL PROPERTIES AND BEHAVIOR OF GLASS

16. **Different Breaking Strength Phenomena of Glass Objects.** A. M. KRUITHOF, N. V. Philips' Gloeilampenfabrieken, Eindhoven (Netherlands).

17. **Strength of Glass and Fracture Process in Modulus of Rupture Tests.** H. SCHARDIN, Universitat Freiburg, Abteilung fur Angewandte Physik, Weil (Germany).
18. **The Splitting of Glass Panes.** B. LONG, Boussois-Glaverdelog, Paris (France).
19. **The Strength and Static Fatigue of Glass.** R. E. MOULD, Preston Laboratories, Inc., (U. S. A.)
20. **Viscous and Visco-Elastic Effects in Glass.** H. T. SMYTH, Rutgers University (U. S. A.).

IV. REFRACTORY CORROSION AND CURRENTS IN GLASS-MELTING FURNACES

21. **Relationship between the Various Textures of Fused-Cast Refractories and Their Resistance to Attack by Glass.** P. GILARD AND C. GILBOUX, Institut National du Verre, Charleroi (Belgium).
22. **The Use of Microscopic Examination under Reflected Light for Studying Electro-Cast Refractories.** P. BORTAUD, TH. GROLLIER-BARON AND M. GARDIOL, L'Electro-Refractaire, Le Pontet (France).
23. **The Selection of Basic Bricks for Glass Tank Regenerators.** T. S. BUSBY, The General Electric Co., Ltd., Wembley (Great Britain).
24. **Studies on the Throat Current of a Bridgewall Tank by Tracer Tests with a Model.** A. NARUSE, Nagoya Institute of Technology, Nagoya (Japan).
25. **Contribution to the Determination of Coefficients of Similitude of Models of Glass Furnaces for Studying Currents in Glass.** R. PATEL, Glaceries de la Cie. de Saint-Gobain, Paris (France).
26. **Dimensional Analysis and its Application to Problems of Glass Technology.** L. LEGER, Union des Verreries Mecaniques Belges, Charleroi (Belgium).

V. PHYSICS AND CHEMISTRY OF GLASS.

27. **Catalyzed Crystallization of Glass in Theory and Practice.** S. D. STOOKEY, Corning Glass Works (U. S. A.).
28. **Reaction Rates and Mechanism in the Systems Na_2O-B_2O_3 and Na_2O-B_2O_3-SiO_2.** V. GOTTARDI AND B. LOCARDI, Stazione Sperimentale del Vetro, Murano (Italy).
29. **The Effects of Heat Treatments on the Thermal Expansions of Some Borosilicate Glasses and Iron-Nickel-Cobalt Alloys and their Significance in the Behavior of Glass-to-Metal Seals.** L. F. Oldfield, General Electric Co., Ltd., Wembley (Great Britain).
30. **Thermal Expansion and Composition of Glass.** S. KUMAR, Central Glass & Ceramic Research Institute, Calcutta (India).
31. **The Properties of Binary Phosphate Glasses.** C. A. ELYARD, P. L. BAYNTON AND H. RAWSON, The British Thomson-Houston Co., Ltd., Rugby (Great Britain).
32. **The Rate of Solution of Oxygen Bubbles in Commercial Glasses.** C. H. GREENE AND I. KITANO, Alfred University (U. S. A.).
33. **Heat Effects in Glass within the Transformation Range.** W. GEFFCKEN AND N. NEUROTH, Jenaer Glaswerk Schott & Gen., Mainz (Germany).

VI. STRUCTURE OF GLASS.

34. **Some Mechanical Properties of Glasses and Crystals as Affected by Changes in Chemical Binding Forces.** W. A. WEYL AND E. C. MARBOE, Pennsylvania State University, (U. S. A.)
35. **The Boron Oxide Anomaly.** J. KROGH-MOE, Chalmers Tekniska Hogskola, Goteborg (Sweden).
36. **The Alumo Boron Anomaly of Silicate Glasses.** A. A. APPEN, Institute for Silicate Chemistry of the Academy of Science, Leningrad (Russia).
37. **The Physical Properties of Invert Glasses.** J. M. STEVELS AND H. J. L. TRAP, N. V. Philips' Gloeilampenfabrieken, Eindhoven (Netherlands).
38. **The Role of Germanium Impurity in the Defect Structure of Silicas and Germania.** A. J. COHEN, Mellon Institute, Pittsburgh (U. S. A.).
39. **Application of the Williams-Landel-Ferry Equation to Silicate Glasses.** A. B. BESTUL, National Bureau of Standards, Washington (U. S. A.).
40. **Infrared Transmission Measurements of Glasses Containing High Proportions of Lead Oxide in Relation to Their Structure.** A. ABOU EL AZM AND A. L. HUSSEIN, National Research Center, Cairo (Egypt).

VII. INFRARED TRANSMISSION OF GLASS.

41. **The Transmission of Glasses in the Near-Infrared at Temperatures up to Freezing Point.** H. SCHOLZE, Max-Planck-Institut-fur Silikatforschung, Wurzburg (Germany).
42. **Non-Silicate Glass Systems for Transmitting Infrared.** H. H. BLAU, Ohio State University (U. S. A.).
43. **The Absorption of Infrared Radiation and the Structure of Glasses.** R. V. ADAMS AND R. W. DOUGLAS, Department of Glass Technology, The University, Sheffield (Great Britain).
44. **Heat Transfer in Glass.** F. J. GROVE AND H. CHARNOCK, Pilkington Brothers, Ltd., St. Helena (Great Britain).
45. **Radial Radiation-Conduction in Long Cylinders.** W. GEFFCKEN, Jenaer Glaswerk Schott & Gen., Mainz (Germany).

History and Design Section

These papers will be delivered in full, with the emphasis mostly on their illustrations. Because of the small number of papers in this section, there will be plenty of time for discussion afterwards.

I. GLASS IN ANTIQUITY

1. **The Excavations at Gordion and their Importance for the History of Luxury Glasses.** A. V. SALDERN, Corning Museum of Glass (U. S. A.).
2. **New Light on Roman and Early Medieval Window Glass.** D. B. HARDEN, The London Museum, London (England).
3. **A Study of the Opalizing Agents in Ancient Opal Glasses throughout Three Thousand Years.** W. E. S. TURNER, Sheffield (England) and H. P. ROOKSBY, General Electric Co. Ltd., Wembley (England).

II. HISTORY OF GLASS.

4. **Contribution to the Domain of Roman Glasses.** A. MAIURI, Antichita della Campania Napoli, Naples (Italy).
5. **Hollow Glass in the Middle Ages under Special Consideration of the Latest Excavations Made in Holland and Elsewhere.** J. G. N. RENAUD, Amersfoort (Netherlands).
6. **Relations between European and American Glass Design.** W. DEXEL, Braunschweig (Germany).

III. HISTORY OF GLASS TECHNOLOGY.

7. **The Technical Study of Ancient Glasses.** W. E. S. Turner, Sheffield (England).
8. **Glass Manufacturing in East and Middle Europe in Antiquity and in the Early Middle Ages.** M. A. BESBORODOW, Minsk (Russia).
9. **Raw Materials for Glass in Antiquity and in the Middle Ages.** W. GEILMANN, Institut fur anorg. und analyt. Chemie der Universitat Mainz, Mainz (Germany).
10. **Glasses of the Renaissance Blown in Closed Molds.** R. CHAMBON, Union des Verreries Mecaniques Belges, Charleroi (Belgium).

IV. DESIGN OF GLASS.

11. **Glass Design in America.** J. M. GATES, Corning Glass Works (U. S. A.).
12. **The Role of Invention and Observation in the Creation of Glass Forms.** M. DAUM, Cristallerie de Nancy, Nancy (France).
13. **Are Aesthetic Aspects to Be Considered in the Development of Glassware?** A. D. COPIER, N. V. Koninklijke Nederlandsche Glasfabriek Leerdam, Leerdam (Netherlands).

V. DESIGN AND APPLICATION OF GLASS.

14. **Aim, Play, Law in Glass Design.** FRHR. E. SCHENK Zu Schweinsberg, Wiesbaden (Germany).
15. **Formal Tendencies of Present Glass Design.** W. ROTZLER, Kunstgewerbemuseum Zurich, Zurich (Switzerland).
16. **Glass and Representative Illumination of Rooms.** H. H. RATH, J. & L. Lobmeyr, Vienna (Austria).
17. **The Efforts of Ravenna for the Renovation of Mosaic-Work.** G. BOVINI, Soprintendenza ai Monumenti della Romagna, Ravenna (Italy).

American Ceramic Society Annual Meeting

Editor's Note: A brief report on the honors and awards which were presented at the 61st Annual Meeting of the American Ceramic Society. A detailed review of the Glass Division technical papers will appear in the July issue of THE GLASS INDUSTRY.

• OSCAR G. BURCH, VICE PRESIDENT, Owens-Illinois Glass Co., was elected president of the American Ceramic Society during its 61st Annual Meeting (May 17-21) at the Palmer House in Chicago. He has been active in the Society for many years, especially in the Glass Division, having been Division vice chairman in 1945 and chairman in 1946.

Mr. Burch was elected to the Board of Trustees in 1953, on which he served for three years, becoming vice president in 1956 and president-elect in 1957. He was a member of the executive committee from 1954 through 1957 and has during this time served on many other committees, both on behalf of the Society and also for the Glass Division.

He received a B. S. Degree in chemical engineering in 1927 and a M. S. Degree in chemistry (1929) from Washington University, St. Louis, Mo., and after graduation joined the Western Electro-Chemical Co., San Francisco, as a sales engineer. In 1931 he joined the Owens-Illinois Alton, Ill., plant as a research chemist, becoming director of the general research laboratory in Toledo six years later.

Mr. Burch became director of the company's research program in 1946 and was elected a vice president in 1950. He is now in charge of the Owens-Illinois Technical Center at Toledo, Ohio, as well as the engineering activities of the company's 58 plants throughout the United States and Latin America.

Other officers elected at the meeting were George Spencer-Strong, Pemco Corp., as president-elect; J. J. Canfield, Armco Steel Corp., vice president; John H. Koenig, Rutgers University, vice president; and James I. Mueller, University of Washington, vice president.

New trustees are A. C. Siefert, Owens-Corning Fiberglas (Glass Division); C. J. Koenig, Ohio State University (White Wares Division); Albert H. Couch, Libbey-Owens-Ford Glass Co. (for the National Institute of Ceramic Engineers); and Joseph A. Pask, University of California (for Ceramic Educational Council).

Oscar G. Burch, newly elected president of the American Ceramic Society. Mr. Burch is vice president, engineering and research, Owens-Illinois Glass Co.

HONORS AWARDED

Two men, Howells Frechette and John D. Sullivan, were named honorary members of the American Ceramic Society. This is the first time two individuals have been so awarded at one time.

Mr. Frechette received the honor in recognition of his long service to the ceramic field as chief of the Division of Mineral Industries, Bureau of Mines, for Canada. He is a past president of the Canadian Ceramic Society, of which he was recently named an honorary life member. He is also a past chairman of the Structural Clay Products Division of the American Ceramic Society, dean of Fellows, and a Life Member.

Mr. Sullivan, assistant director of Battelle Memorial Institute, and a past president of the American Ceramic Society, has held many offices in the Society and in the Refractories Division. He received this latest Society recognition for his leadership in ceramic research.

Annual Student Speaking Competition

Ashok Savant, a student at the University of Washington, won the speaking competition among eleven contenders for his paper on "A New Low-Expansion Ceramic with Improved Thermal Shock Resistance."

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WATER IN THE GLASS STRUCTURE

By H. Scholze

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WURZBURG, GERMANY

Translated by: Thomas H. Elmer

• INFRARED INVESTIGATIONS in the region of 3 microns have been made on binary alkali silicate glasses and some simple ternary glasses of different composition. Characteristic changes of the OH-band at 2.75 to 2.95μ were observed which depended upon the composition of the glass. This effect is explained by differences in influence of the water on the OH-band in glass. Consequently conclusions may be drawn on some properties of glass.

It has been known for a long time that water is not only adsorbed on glass but that glass contains appreciable amounts of water. Table 1 gives the results of a number of gas-analytical investigations by various authors for soda-lime glasses and borosilicate glasses.

Table 1

H_2O and CO_2 Content in Glasses (In cm^3 of gas under standard conditions per 100 gms. of glass)

Author	Type of Glass	H_2O	CO_2
Salmang and Becker [1]	soda-lime glass	40	3
Dalton [2]	Soda-lime glass	33	7
	borosilicate glass	74	1
Dalton [3]	soda-lime glass	28	9
	borosilicate glass	93	3
Hahner, Voight and Finn [14]	soda-lime glass	25	14-50 ($CO_2 + SO_2$)
	borosilicate glass	40	0.1

The first infrared studies of glasses, especially of fused silica, showed an absorption band at 2.7 to 3.0 microns wavelength. At first this band was ascribed to Si-O vibrations, then it was assumed to result from CO_2, and finally it was said to be due to O-H valency vibrations which lie in this range.

Harrison [5] showed that this band decreases markedly when the glasses are degassed. In her work it was further shown that the position of the band shifts from 2.70 to 2.85; to 2.95 and to greater than 3.2 microns wavelength for fused silica, B_2O_3- glass, borax glass and metaphosphor-type glass, respectively. Harrison assumes the water in fused silica is present in the monomeric state and that the shift of wavelength corresponds to increased bonding. If the glass components are strongly bound the bonds holding the water become weaker.

Lyon and Kinsey [6] have made general investigations regarding the presence of water in silicates. These authors assume that water is bound in three different ways. The OH bands of beryl (2.710 and 2.780 microns) are comparable with the bands of water dissolved in CCl_4 (2.699 and 2.767 microns). Since beryl crystals contain open channels having a diameter of 4.2 A, the water may be present as "coordinated" water. The band in fused silica (2.723 microns) corresponds to the band of a solution of water in pyridin (2.719), and consequently it is assumed that water is in solid solution in the structure. Finally in muscovite H-bonding is assumed to be absent and only OH groups are assumed to exist (1 band at 2.747 microns).

Extensive infrared studies of glasses were also carried out by Florence and co-workers [7-9]. The 2.75 micron band is assumed to be due to water vapor; the 2.95 micron band in most other glasses examined is assumed to be due to liquid water in the glass structure. Furthermore the better transmittance of a number of PbO- and BaO-containing glasses in the near infrared is correlated with Weyl's theory. Weyl assumes that since these glasses have a lower hygroscopicity the glass may possibly show similar effects.

In the works mentioned conclusions were drawn from the position of the OH-Bands regarding the type of bonding of water. In the last few years a number of articles appeared on this problem in which a simple correlation was found between the position of the OH-band in crystals and the spacing of oxygen in the hydrogen bond O-H. . . . . O [10-12]. The OH band is shifted to longer wave lengths as the O-O distance decreases. The cations present in the crystal affect only the arrangement of the oxygen packing.

It was assumed that the latter findings will shed light on how water is held in the glass structure. The infrared measurements presently available are not sufficient to enable one to make an evaluation. For this reason additional measurements were made.

Experimental Part

Glasses in the system SiO_2-Li_2O, SiO_2-Na_2O and SiO_2-K_2O were investigated. The higher alkali-containng glasses were melted in platinum crucibles in a gas-fired furnace. The lower alkali-containing glasses were melted in molybdenum boats in forming gas. The batch material consisted of chemically pure alkali carbonates. In order to obtain seed-free melts for infrared investigations Dörentruper quartz sand was used as silica source. The small amount of impurities had to be tolerated to accomplish this. The compositions of the glasses investigated are given in Table 2. The only analytical

Delivered at the Fourth International Glass Congress, Paris, France, July 1956.

tests carried out were alkali and B_2O_3 determinations. The former was determined as sulfate; the latter was calculated after reacting the glass with HF/H_2SO_4. The silica content was obtained by difference. A few control tests, by which the silica content was directly determined, showed this method was justified. It is interesting to note that there was an enrichment in alkali content and R_2O_3 content in low alkali-containing glasses melted at high temperatures in forming gas containing 80 per cent N_2 and 20 per cent H_2. The increase in the alkali content in these glasses was due to vaporization of silica. (See glasses No. *2, 3, 4, 13, 14, 15, 23, 24, 25*). Patties, 1 to 2 mm thick, were poured from the melts and annealed. If the surfaces of the patties were not parallel or if the melt did not pour satisfactorily, the patties were ground in absence of water. The infrared measurements were carried out with a Leitz Infrared-Spectrophotometer using a NaCl prism. This unit operates automatically. The measuring accuracy for the glasses was 0.02 micron.

Experimental Results

In pure fused silica the OH band was found to be at 2.75 microns which is in agreement with data reported earlier by other authors. Small amounts of alkali do not alter the position of this band. Further addition of alkali causes the band to shift toward longer wavelengths. The maximum of this band was still clearly defined in glasses No. *12* containing 29.1 mole per cent Li_2O. However this maximum was obscured in the case of Na_2O glasses, and especially in the case of K_2O glasses with higher alkali content, by a broad band having a maximum at about 3.6 to 3.7 microns. Because of this, the shift of the maximum could no longer be determined. The position of the maxima of OH-24 bands for the glasses studied are given in the last column of Table 2. The dependency of the shift on alkali content is graphically presented in Fig. 1. In the case of Na_2O-glasses the shift of the OH-band toward longer wavelengths occurs at lower alkali concentrations than in the case of Li_2O-glasses. The K_2O-glasses could not be included in this diagram because the maxima of the OH-band is already obscured at a K_2O content of 6.2 mole per cent.

Figures 2-4 show transmittance curves for Li_2O, Na_2O and K_2O-glasses giving a calculated alkali-oxide content of 3, 15, and 25 mole percent. In addition to the shift of the OH-band, the experimental data show that the intensity of the OH-band decreases with increasing alkali content and that the intensity of the broad 3.6-3.7 micron-band increases. (Glasses in this series were all melted under the same conditions.) This can be seen in Figures 2-4 in the case of curves for 15 and 25 mole-per cent glasses. The 3 mole-per cent glasses cannot be used in this comparison because they were molten at a higher temperature.

Control curves made on very thin plates (0.1 mm), which showed no absorption in this region, indicated that these absorptions are not due to surface effects.

Discussion

The experimental results at first lead to two questions.

1. The decrease in intensity of the OH-band with

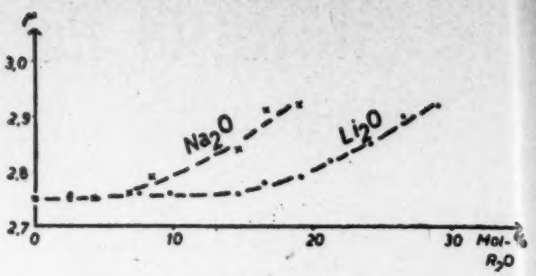

Fig. 1.

Position of OH band of binary glasses SiO_2-Li_2O and SiO_2-Na_2O.

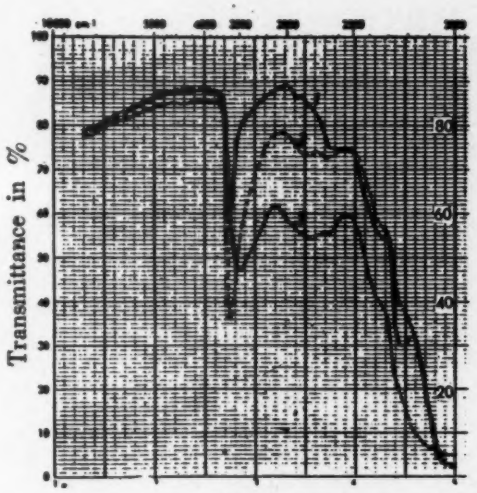

Fig. 2.

Infrared transmittance of Li_2O-SiO_2 glasses (sample thickness 1.5 mm).
Curve 1: Glass No. 3 (3 mol.% Li_2O).
2: Glass No. 6 (15 Mol.% Li_2O).
3: Glass No. 10 (25 Mol.% Li_2O).

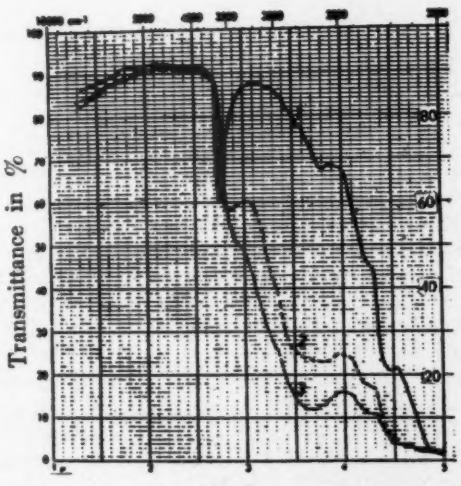

Fig. 3.

Infrared transmittance of Na O-SiO glasses (sample thickness 1.5 mm).
Curve 1: Glass No. 14 (3 Mol.% Na_2O).
2: Glass No. 17 (15 Mol.% Na_2O).
3: Glass No. 21 (25 Mol.% Na_2O).

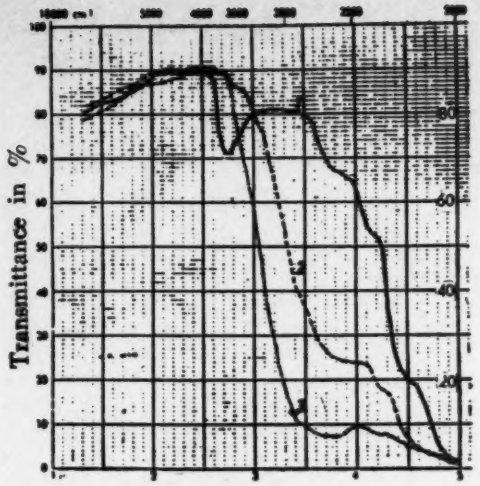

Fig. 4.
Infrared transmittance of K_2O-SiO_2 glasses (sample thickness 1.5 mm).
Curve 1: Glass No. 24 (3 Mol.% K_2O).
2: Glass No. 28 (15 Mol.% K_2O).
3: Glass No. 32 (25 Mol.% K_2O).

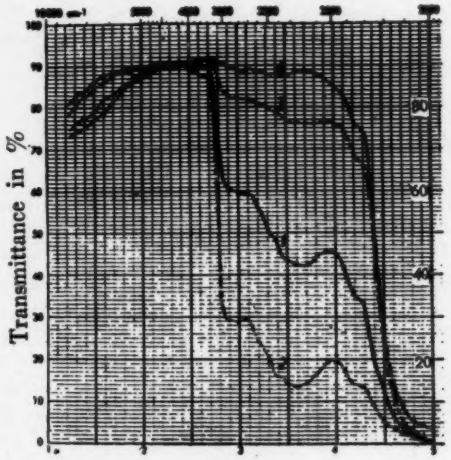

Fig. 5.
Infrared transmittance of a soda-lime glass (sample thickness 1.5 mm).

Curve 1 : melted with Na_2CO_3
2 : melted with $Na_2CO_3 \cdot 10H_2O$
3 : melted with $Na_2CO_3 \cdot 10D_2O$
4 : melted in vacuum

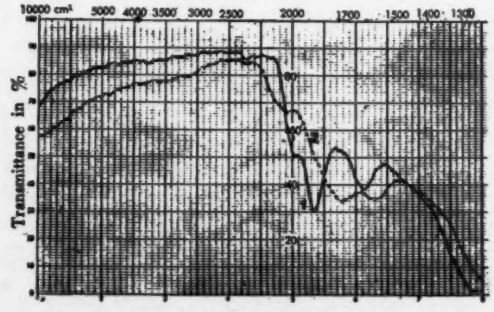

Fig. 6.
Infrared transmittance of a fused silica sample, 0.05 mm thick (curve 1) and a soda-lime glass, 0.09 mm thick (curve 2).

increasing alkali content indicates a decrease in water content. But such an explanation is unsatisfactory. It is true that Table 1 shows that the borosilicate glasses (which one can set equal to glasses with low alkali content) contain more water than soda-lime glasses, but one cannot assume that the water content, for example of glass No. 32 with 25 mole-per cent K_2O, can become negligible as might be concluded from the infrared diagram. (See Fig. 4).

2. In what form is the water held in the glass? As molecular H_2O or as OH groups? The OH band at 2.7 to 3.0 microns does not give any information on this because it is produced by O-H valency vibrations and is therefore present in both H_2O and OH groups. A decisive answer can be obtained only at 6.25 microns, a wavelength which causes deformation vibrations in water.

The following experiments were carried out.

Experiment

1. The broad band at 3.6 to 3.7 microns (Fig. 2) which obscures the OH band is assumed to be due to carbonation according to Florence and co-workers[8]. These authors base their explanation on work by Schaefer and co-workers[13] which showed that carbonates have absorption bands at 3.4 and 3.9 microns. Melting with nitrates improves the transmittance in this region only

(*Continued on page* 338)

Table 2

Composition of Experimental Glasses and Positions of OH-Band

No.	Alkali Me_2O	Mole % Me_2O (calculated from batch)	Analysis (in weight %) Me_2O	Me_2O_3	Mole % Me_2O (from analysis)	Position of OH-band (microns)
1	—	0	—	—	—	2.75
2	Li_2O	1	1.33	0.72	2.6	2.76 (2)
3	—	3	2.35	0.48	4.6	2.75 (2)
4	—	6	3.92	0.35	7.6	2.76 (2)
5	—	10	5.20	0.22	9.9	2.76 (2)
6	—	15	7.94	0.20	14.8	2.76
7	—	17.5	9.04	0.42	16.7	2.78
8	—	20	10.65	0.38	19.3	2.79
9	—	22.5	11.90	0.23	21.4	2.82
10	—	25	13.90	0.42	24.5	2.85
11	—	27.5	15.31	0.35	26.7	2.90
12	—	30	17.02	0.52	29.1	2.92
13	Na_2O	1	2.60	0.83	2.5	2.75 (2)
14	—	3	4.25	0.70	4.1	2.75 (2)
15	—	6	6.26	0.40	6.1	2.76 (2)
16	—	10	8.80	0.62	8.6	2.79 (2)
17	—	15	15.28	0.53	14.9	2.84
18	—	17.5	17.85	0.33	17.4	2.91
19	—	20	19.60	0.32	19.1	2.92
20	—	22.5	22.81	0.22	22.2	(1)
21	—	25	24.62	0.45	24.1	(1)
22	—	27.5	27.80	0.23	27.2	(1)
23	K_2O	1	3.44	0.83	2.2	2.75 (2)
24	—	3	6.10	0.70	4.0	2.75 (2)
25	—	6	9.29	0.25	6.2	(1) (2)
26	—	10	13.24	0.41	8.9	(1) (2)
27	—	12.5	17.85	0.14	12.1	(1)
28	—	15	21.31	0.33	14.7	(1)
29	—	17.5	24.89	0.35	17.4	(1)
30	—	20	27.57	0.20	19.6	(1)
31	—	22.5	30.69	0.33	22.2	(1)
32	—	25	33.71	0.27	24.5	(1)

(1) No maximum perceptible.
(2) Melted in a molybdenum boat in forming gas.

GOLD FILMS PART TWO

By Samuel Wein

CONSULTANT

Organic Gold Compounds

Professor Gibson and his students found that if diethylmonobromogold ($AuC_2H_5Br_2$) were dissolved in a suitable solvent such as ethanol, to which an alkali had been added, the compound would have interesting decomposition properties, even at room temperatures, and it would form gold mirrors on many surfaces. It was found that the solution became deeply colored, like those of collodial gold, in a short time (seven to nine minutes), and a gold film would be deposited on the surface as a coherent film. Gibson and Nield published privately a pamphlet describing these compounds.

Brilliant films of gold have been deposited on glass and other surfaces. By reflected light they appear as massive gold and by transmitted light they show the characteristic colors of thin gold films. The films are capable of being polished, but they can be produced in such a manner as to render this unnecessary. The thickness of the films can be varied by altering the conditions of the reaction and the quantity of the reactants.

The following are examples of gold compounds which Professor Gibson and his students have prepared and found suitable for the process of forming gold films.

To form a film of gold on glass, Professor Gibson recommended the following:

Example 1

Diethylmonobromogold	0.335	part
Ethanol	42.0	parts
Sodium hydroxide	0.08	part

The mixture is well shaken and the resulting solution poured onto the glass surface. The gold film forms in 5 to 10 minutes and is complete in from 25 to 30 minutes. After the deposition, the residual solution is removed and the film washed, with, for example, successive quantities of ethanol or with water, ethanol and then with ether, and allowed to dry.

An alternative method may be made up of:

Example 2

Diethylmonobromogold	0.18	part
Ethanol	32.0	parts
Sodium ethylate	0.0731	part
Water	1.1	parts

The glass may be rocked gently for about 30 minutes during which the film of gold will be deposited. The residual solution is then removed and the surface washed three times with ethanol and allowed to dry.

For forming gold films on the inner walls of a glass globe, the following solution is recommended.

Example 3

Diethylmonobromogold	0.2	part
Ethanol	162.0	parts
Sodium ethylate	0.812	part
Water	10.6	parts

It is well to rotate the glass ball for abouth 7 minutes when the gold film will be seen to form; in 40 minutes the film will have been completed, after which it is washed.

The following formulation is recommended to form gold films on textiles; for instance, on a piece of silk:

Example 4

Diethylmonobromogold	0.11	part
Ethanol	33.5	parts
Sodium ethylate	0.0447	part

The silk is submerged in this solution for about 2 hours and the container slowly rotated. After the gold has formed on the silk, it is washed thoroughly in ethanol and dried.

For use with Bakelite, Professor Gibson recommended:

Example 5

Diethylmonobromogold	0.1	part
Ethanol	16.0	parts

To the foregoing there is added 0.0406 part sodium ethylate dissolved in 1.2 parts ethanol.

A freshly planed and seasoned oak having a surface area of 40.5 sq. cm. is made the base of a cell with glass sides. The interior surface of the glass sides are coated with paraffin. The solution recommended for coating the wood is made up of:

Example 6

Diethylmonobromogold	0.04	part
Ethanol	8.0	parts

and to this is added:

Sodium ethylate	0.0162	part
Ethanol	0.4	"

The mixed solution is poured over the surface of the wood and allowed to remain in contact with it for 45 minutes. The solution is then removed and the wood thoroughly washed. A coherent gold film is found on the wood.

A piece of aluminum having a curved surface is cleaned just before use by gently rubbing it with cotton wool. The cotton wool should first be immersed in a cold and very dilute solution of sodium hydroxide, then thoroughly washed with water, and, finally treated with:

Example 7

Diethylmonobromogold	0.05 part
Ethanol	.80 "

and to this is added:

Sodium ethylate	0.023 part
Ethanol	0.6 "

This mixed solution is poured into a vessel; the aluminum is suspended and slowly rotated for one hour, then removed and washed with ethanol. The surface of the aluminum will be found covered with a film of gold.

Example 8

Diethylmonobromogold	0.1 part
n-butyl alcohol	16.0 parts

To this solution (Example *8*) in a glass vessel is added 0.0573 part of sodium n-butylate contained in two parts of n-butyl alcohol. The deposition of the gold film takes a little longer to begin than in the previous case, but after some 50 minutes shows little difference.

Example 9

In example *9*, 0.05 part of diethylmonobromogold is dissolved in 20 parts of ethanol and mixed with 0.0203 part of sodium ethylate contained in 0.4 part of ethanol. The solution is poured into a clean, stainless steel, circular dish. The loosely covered dish and contents are gently rocked for thirty minutes. The solution is then removed and the dish washed in the manner described above. A gold film is found deposited on the surface which had been in contact with the solution.

Example 10

In example *10*, 0.35 part of di-n-propylmonocyanogold is dissolved in 8.0 parts of ethanol by warming to 50° C. The solution becomes cloudy on cooling to the ordinary temperature. To this is added 0.184 part of sodium ethylate contained in 0.8 part of ethanol. On thorough mixing the solution becomes clear, and it is transferred to a clean vessel and allowed to stand at ordinary temperature. A film of gold begins to deposit slowly and continues to form during three hours.

Example 11

A result similar to that of example *9* is obtained when sodium hydroxide in aqueous solution in equivalent amount is used instead of sodium ethylate in ethanol. All other conditions are the same.

Example 12

Here, 0.2 part of the compound of example *9* is dissolved in 2.6 parts benzene, and to this is added 0.088 part of sodium ethylate contained in 2.9 parts of ethanol. The mixed solution is transferred to a clean glass vessel and allowed to remain at room temperature. A film of gold is deposited slowly and continues to develop during four hours.

Example 13

In this instance, 0.5 part of tetraethylmonosulphategold is dissolved in 8 parts of ethanol, and to this solution is added 0.224 part of sodium ethylate contained in 0.8 part of ethanol. The mixture is transferred to a clean glass vessel on the sides of which a gold film is deposited, where the solution makes contact with the glass, in twenty five to thirty minutes.

Example 14

Here, 0.1 part of diethylmonobromogold is dissolved in 16 parts of n-butyl alcohol and mixed with 0.0406 part of sodium ethylate contained in 2 parts of ethanol in a clean glass vessel. The solution darkens, and the film begins to deposit on the surface in contact with the solution in about 13 minutes. It continues to form during some hours.

Example 15

In this example, 0.1 part diethylmonobromogold is dissolved in a clean glass vessel in 20 parts benzyl alcohol; this is mixed with 0.0406 part sodium ethylate contained in 2 parts of ethyl alcohol. The mixture becomes dark colored almost immediately, and within two minutes a gold film begins to form on the glass.

Example 16

Here, 0.25 part diethylmonobromogold is dissolved in 40 parts iso-propanol contained in a clean vessel. To this solution is added 0.06 part sodium hydroxide dissolved in 3 parts water. The mixture becomes rapidly dark colored and a gold mirror begins to form within 1 hour.

Example 17

This time, 0.1 part diethylmonobromogold is dissolved in 16 parts ethanol; to this is added 0.07 part sodium phenate contained in a mixture of 2 parts of ethanol and 0.7 part water. The mixed solution is transferred to a clean glass vessel in which a film of gold begins to form slowly and continues to develop during several hours on the glass.

Ketones

Professor Lenher records that the ketones will deport themselves in a manner similar to the aldehydes when brought in contact with gold chloride solutions. In alkaline solution the ketones as a class precipitate metallic gold more or less rapidly.

Photographic Developers

Professor Lenher lists the following organic photographic developers. He states that when an aqueous solution (either acidified with hydrochloric acid or made slightly alkaline with sodium hydroxide) is when brought in contact with the gold chloride solution, they react to precipitate metallic gold instantly without apparently producing the intermediate stage of aurous chloride.

The developers he lists are Adurol, Amidol, Dianol, Edinol, Eikonogen, Glycine, Hydroquinone, Metol, Metolquinone, Ortol and Pyrogallol. This listing is in alphabetical order; not in the order of reducing effectiveness.

Phosphorous

In keeping with the early work of Mrs. Fulhame, Eidlitz patented in 1860 the following technique. A film of photogelatine is formed on a given surface and in turn is mordanted (made insoluble by varnishing and subsequent treatment with potassium dichromate and exposed to a source of light). Thereafter the film is treated with a solution of copper sulphate, subsequently washed with running water, and transferred to a solution of gold chloride. This is then exposed to the vapors of

phosphorous to form the film of metallic gold.

Sugars

One of the formulas often mentioned and first recommended is that accredited to Professor Boettger:

1) Gold chloride	2 grams
Water	100 c.c.
2) Sodium hydroxide	6 grams
Water	100 c.c.
3) Grape sugar	24 c.c.
Water	24 c.c.
4) Alcohol	24 c.c.
Formaldehyde	24 c.c.

The actual gilding solution is made up of:

Solution 1	64 parts
Solution 2	16 "
Solution 3	1 part
Solution 4	48 parts

The formula, if carefully made up, works well. It is found, however, that the neutralization with sodium hydroxide is rather difficult. The slightest excess of base increases the sensitivity of the solution towards the reducing solution in such a way that lumps of gold scum form within the solution before gold crystals settle on the glass. The substitution of sodium carbonate for sodium hydroxide helps a great deal in this respect.

Loiseleur treated cellulose acetate sheeting with a solution of cupro-ammoniacal compound, made up of one quarter mole of copper hydroxide and 2 moles of ammonia per liter. The cellulose acetate sheeting is then washed in running water, again treated with a solution of tin chloride, once more washed in running water, and finally gilded with the following solution:

Sodium gold oxide	2.0 grams
Glucose	0.25 gram
Levulose	0.25 "
Sodium tartrate	0.025 "
Water	1000 c.c.

After drying, the gold deposit is capable of receiving a fine polish under the action of a soft leather.

Cowper-Coles made a paste of tin chloride using jewelers rouge as the binder. This was rubbed over the glass surface and subsequently washed off. The gold solution he used was made up of:

Gold chloride	1 per cent
Sodium hydroxide	7 " "
Glucose	5 " "

A spraying compound accredited to Andres is made up of:

1) Gold chloride	1 ounce
Water	1 gallon
2) Potassium carbonate	1½ ounces
Water	1 gallon
3) Grape sugar	35 grains
Water	2 gallons

Of solution *2* take ½ fluid ounce; add 1 fluid ounce of solution *3*, then add 2 to 4 ounces of solution *1*.

If a darker gold film is desired, a silvering solution containing a little copper tartrate may be added to the gilding solution.

Gold mirrors were produced by Petitjean as early as 1855 by precipitating gold out of solution using sodium tartrate as the reducing agent. This solution is formed by combining two equivalents of gold chloride with one equivalent of ammonium citrate. Dissolve 1 ounce of gold chloride; to the filtered solution there is added 10½ drams citric acid previously dissolved in 4 to 5 times its weight of water with 5½ drams ammonia. After allowing this to stand for an hour or more to cool, this is poured into the gold chloride solution.

Professor Pollard successfully used the following formulation, which appears to be the same as that referred by Kanthavk in his bibliographical survey. In this recipe, however, coal gas was passed through solution *3* for one hour. The three solutions are:

1) Gold chloride	10 per cent
2) Sodium hydroxide	7 " "
3) Alcohol	2 parts
Glycerine	1 part
Water	1 "

The process is a simple one; i.e., the glass is first boiled in ammonia, then in a 1 per cent tin chloride solution and rinsed. The actual gilding solution is made up of:

Small quantity. Mix 5 drops of solution *2* with *3* drops of solution *3* and dilute to 4 c.c. To this add 5 drops of solution *1* and allow this to stand in the dark.

Large quantity. Mix 5 parts of solution *2* and 1 part of solution *3*, dilute to 80 parts of water, then add 5 parts of solution *1*.

Another investigator with glycerine solutions of gold is Panasyuk.

Pratt first treated the cleaned glass surface with a diluted solution of tin chloride and rinsed. The actual gilding solution consisted of:

1) Sodium hydroxide	1 part
Water	20 parts
2) Gold chloride	3 "
Water	40 "
3) Glycerine	1 part
Water	1 "

To the foregoing solution there was added several drops of a mannite solution.

In order to thicken the gold film, a film of silver is precipitated on top of the previously formed gold film. This is subsequently lacquered.

The temperature of the gilding solution is between 150° and 200°F.

Herrmann first treats the glass surface with a diluted gold chloride solution containing no reducing agent forming as it does an invisible film of gold. Subsequently a thicker film of gold is deposited on the initial gold film but the present solution contains a reducing agent (hydrogen peroxide), the temperature of which is in the neighborhood of 77°F.

The actual gilding solution contains 1 c.c. of a 1/100 normal solution of potassium gold chloride made up of 2 grams of metallic gold to the liter. To this is added 1 c.c. of a 60 c.c. standard potassium hydroxide solution to which 250 c.c. of absolute ethyl alcohol and 70 c.c. distilled water has been added. This solution is poured over the glass surface, and in due time it changes from a clear to a dark solution. The surface is now washed with running water. The rate of gold deposition de-

(*Continued on page* 330)

Devitrification and Thermal History

By Oscar Knapp

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• TAMMANN HAS DEVELOPED a theory of the devitrification behavior of glassy materials. According to his generally accepted theory, this behavior largely depends upon two factors: the ability to crystallize and the rate of crystal growth. The ability to crystallize, or the facility of crystallization, is measured by the number of originated crystal centers (nuclei) per unit of mass or area at a given temperature. The rate of crystal growth is the greatest increase in length of a crystal per unit time.

Kittle established that, in addition to the above-mentioned properties, viscosity and rate of annealing also play a role in devitrification.

According to Tammann's theory, the ability to crystallize is extremely sensitive, and varies with the thermal history of the liquid glass. He observed that the higher the temperature and the longer the time of heating, the smaller the number of crystal centers in the piperonal investigated. He was studying organic compounds, and neither he nor other researchers studied the influence of thermal history on the crystallization of silicate glasses.

In order to get a deeper and more extended insight into the essentials of devitrification, I have made some investigations which tended to clarify the relation between devitrification and thermal history.

Two sets of studies were made. In the first, glass specimens have been devitrified below the liquidus temperature and afterward heated above that temperature, and the dissolving of the crystals has been observed.

In the second set of experiments, the glass specimen was previously heated at a temperature above the liquidus, and afterward devitrified at a lower temperature, and the crystallization properties were observed and measured.

Results

An alkali-lime-magnesia-silica glass, of composition previously reported, was devitrified at 700°C. for 6 hours. The devitrified glass was then placed in a furnace at 850° C., and removed and examined at 30-minute intervals. The crystal film on the surface did not disappear after a heat treatment of 90 minutes; notwithstanding the fact that the clear glass would not show any crystal separations at that temperature. Upon a rise in temperature to 900°C., the crystals dissolved only after an additional 60 minutes.

This experiment establishes the fact that devitrification can persist above the liquidus temperature and disappears there only after a relatively long heat treatment; that is, at temperatures at which clear glass does not devitrify. Crystals in the glass require a long time for solution. Thus, the liquidus, i.e., the maximum temperature at which crystals can exist in the glass, is a limiting temperature and characteristic only when devitrification has not previously been brought about by heat treatment, which is to say, the glass has no thermal history. Otherwise, crystals may remain until sustained heating.

In the second set of investigations, the same alkali-lime-magnesia-silica glass was heated at 900°C. (above its liquidus) for an hour, and after it was cooled, its devitrification behavior was observed. Another specimen of the same glass was heated for 5 hours at 900°C., cooled down to 700°, and examined for devitrification behavior. The 700° temperature was chosen because previous studies had found the maximum rate of crystal growth at that temperature.

Table 1

Crystal size of magnesia glass with thermal history

	Microns					
	60 Minutes	*120 Minutes*	*240 Minutes*	*360 Minutes*	*540 Minutes*	*720 Minutes*
600°C	—	—	—	—	—	—
650°C	—	0.3	2.0	4.0	4.0	4.0
700°C	—	1.0	4.0	6.0	10.0	17.0
750°C	—	3.0	6.0	13.0	16.5	20.5
800°C	—	—	—	—	—	1.5
850°C	—	—	—	—	—	—

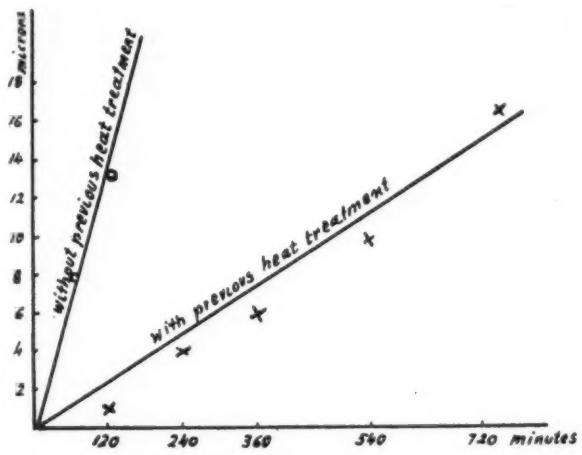

Fig. 1. Crystal size vs. time of magnesia glass after heat treatment at 900°C for one hour.

The result of the one-hour treatment is summarized in Table I. The data are plotted on Fig. I, which demon-

(*Continued on page* 326)

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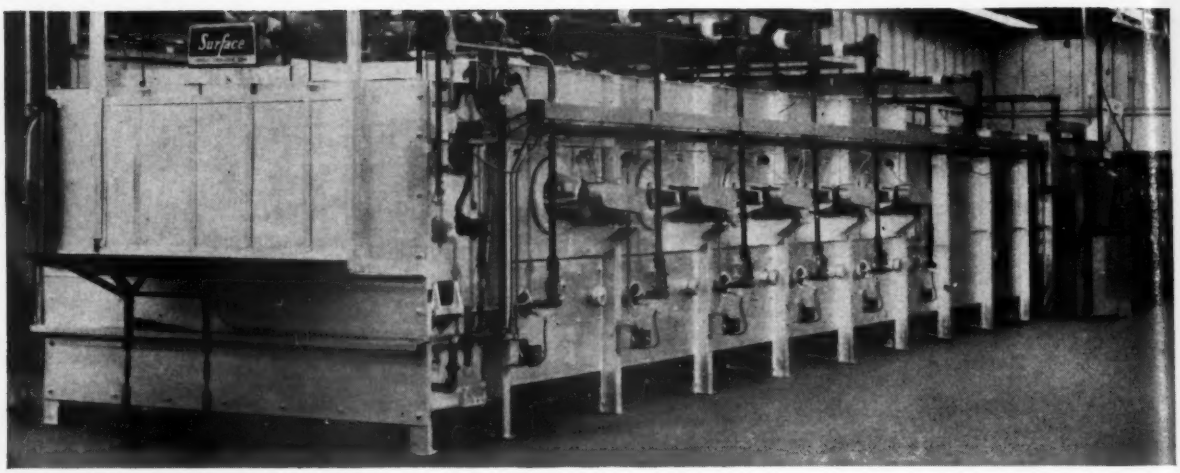
The Surface modular lehr offers a final solution to the company which wants to replace obsolete equipment, but dreads the excessive engineering costs of new units.

This lehr is really a series of standardized modules, which can be linked together to reproduce any prescribed temperature curve. This type of design saves you money because it spreads the engineering costs over many modules, and makes assembly fast and economical.

This lehr has many other features. In many cases, it makes replacement more profitable than retaining outmoded equipment. Please let us tell you more about it.



The new Surface modular lehr, annealing television tubes.

Surface Combustion Corporation
2378 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ont.

wherever heat is used in industry

Surface

NEWS in The Glass Industry

Curts Appointed by American Potash

Robert M. Curts

Robert M. Curts has become manager of glass and ceramic industry sales, American Potash & Chemical Corporation. At the same time he will continue as manager of boron product sales.

Prior to joining American Potash in 1931 in sales development he had been with New Jersey Zinc Co. in technical service sales.

New Chapter for ASGS

The American Scientific Glassblowers Society formed a new chapter in Los Angeles on May 8, the date of the first meeting. The group held elections for officers and a Board of Directors and drew up a local charter which will be presented to the National membership for acceptance.

Owens-Illinois Executive Appointments

Alec M. Turner, vice president of Owens-Illinois Glass Company since 1953 and general manager of the Libbey Glass division since 1955, is now in charge of a newly created corporate planning department of Owens-Illinois. This department has been created, according to President Carl R. Megowen, in order to give increasing emphasis to long-range planning.

Mr. Turner first joined the company as a trainee at the Charleston, W. Va., plant in 1934. Seven years later, he became manager of the Gas City, Ind., glass container plant at the age of 28, the youngest plant manager in the company's history. He later served as the Oakland, Calif., plant manager and Pacific Coast division vice president and general factories manager. In 1953 he returned to Toledo as Owens-Illinois vice president and diector of personnel administration.

George B. Skinta, general sales manager of the Libbey Glass division, succeeds Mr. Turner as general manager of that division.

Ted H. Harbaugh, sales research manager of the Libbey division for the past year, is now general sales manager, replacing Mr. Skinta.

Robert W. Ferrell, formerly marketing management executive of General Electric Company, has been named to the new post of director of marketing development for Owens-Illinois. Through this appointment the company is placing increasing importance on marketing planning in management operations.

Hahn Technical Manager of Johns-Manville

William P. Hahn

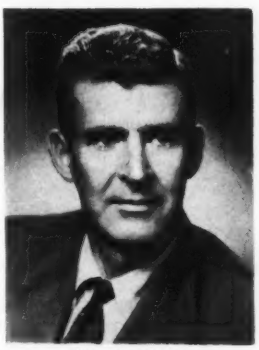
William P. Hahn has been appointed technical manager of Johns-Manville Fiber Glass Inc., a newly-created post.

Mr. Hahn will direct technical and experimental activities in product and process development and supervision of the product planning department. He will also supply manufacturing departments and J-M sales divisions with technical assistance in manufacturing and marketing new product lines.

Watson, Quality Control Mgr. at Hazel-Atlas

Robert W. Watson has been appointed manager of quality control, Hazel-Atlas Glass division, Continental Can Company. He replaces Isaac H. Strider who has resigned for health reasons.

He had formerly been quality control manager at the central metal division in Coffeyville, Kan.



Alec M. Turner

George B. Skinta

Ted H. Harbaugh

Robert W. Ferrell

N. J. Kreidl

A. F. Bischoff

Kreidl on Advisory Panel, N. B. S.

N. J. Kreidl has been appointed to the advisory panel, National Bureau of Standards (mineral products division), by the National Academy of Sciences of the National Research Council.

Westinghouse Designs 2 New Fluorescent Lamps

Westinghouse Electric Corporation has designed a single-ended fluorescent lamp of high efficiency which can be mounted in one socket similar to the conventional incandescent lamp. The new lamp does not require wiring for the other end. In addition to the single-ended lamp, the company has also designed a U-shaped fluorescent tube with all electrical connections at one end.

Glass-blowing Display Honors Corning

A special tribute was paid to Corning Glass Works' new building in New York last month by the Manhattan Savings Bank at 47th and Madison Avenue which featured a 2-week exhibit of glass in the lobby. On display were a Fiberglas sailboat, examples of historical glass, a 200-pound piece of cullet, missile nose cone of Pyroceram, and several Fiberglas decorating fabrics.

During the first week, Patrick Keeler, of Corning, demonstrated basic glass-blowing methods, while Miss Grace Howell, who specializes in miniature work, demonstrated Bohemian glass blowing, for the duration of the exhibit. Miss Howell used rods, tubes and colored glass and pointed out that her family is one of five in the United States using this method.

Miss Grace Howell practising the art of glass blowing in traditional Bohemian style, using rods, tubes and colored glass. The event took place during the Manhattan Savings Bank's special tribute to Corning Glass Works' new building.

Bischoff Under New Management

Bischoff Sons & Company, Culloden, West Virginia, has been purchased by Anthony F. Bischoff, a partner in the firm. The business, which will continue under the name of A. F. Bischoff Glass, Inc., produces a variety of items including lighting, ornamental, tableware and bar-ware glass.

Pennsylvania Glass Sand Scholarships

Twelve colleges and universities will receive the Pennsylvania Glass Sand Merit Award Scholarships for the 1959-60 year from Pennsylvania Glass Sand Corp. One in each university and college to that junior student attaining the highest scholastic average during the third year. The recipient is entitled to full tuition for his senior year in ceramic engineering.

Schools participating in the Merit Award Program for the coming year are: Alfred University, Clemson Agricultural College, Georgia Institute of Technology, Iowa State College, Ohio State University, Pennsylvania State University, University of Illinois, University of Missouri, University of Texas, University of Washington and Virginia Polytechnic Institute.

Battelle Study on Depleted Uranium

The Battelle Memorial Institute, Columbus, Ohio has been sponsored by the Atomic Energy Commission to study how, and in what quantities, depleted uranium can be used by industry for non-nuclear peaceful purposes.

The three-month study, which will end in June, follows the Commission's decision to remove restrictions on non-nuclear uses of uranium from which most of the fissionable U-235 has been removed. Prior to World War II uranium and its compounds had limited use as a coloring agent in glass and glazes, as a component in some ferrous and nonferrous alloys, and as a chemical agent in photographic films, negatives and prints.

Solvay Executive Promotions

Wilbur H. Brumfield has been appointed executive vice president and Raymond Largent, vice president, of Allied Chemical Corporation's Solvay Process division.

Mr. Brumfield has been with Solvay since 1935, during which time he has been assistant to the director of operations, assistant to the president and vice president, respectively. Mr. Largent began as an engineer in the research & development department in 1937 and has been assistant director of development since 1958. His new position will include responsibility for all of Solvay's operating functions.

Bennett D. Buckles becomes assistant to the president; Dr. Robert H. Reed, assistant director of development, succeeding Mr. Largent; A. Gregg Noble, director of purchases, a newly created post; and Dr. Herbert C. Wohlers, director of research.

L.O.F. Elects Six V.P.'s

Harold M. Alexander has been elected vice president of technical services, for Libbey-Owens-Ford Glass Company, with Horace G. Orser, vice president, special products production; A. P. Plant, vice president, industrial sales; E. R. Pierce, vice president, distributor sales, and Clinton F. Hegg and James M. Ashley, vice presidents of sales and public relations, respectively.

Re-elected officers are John D. Biggers, chairman; George P. MacNichol, Jr., president; C. W. Davis, executive vice president, production; F. E. Casayoux, vice president, finance; S. S. Wall, vice president and general counsel; W. H. Hasselbach, vice president, engineering; E. M. Everhard and L. G. Bryan, vice presidents. Ross S. Carey has been re-elected secretary; R. M. Weter, treasurer, and Harry B. Ryan, comptroller.

VP's Named for Owens-Corning

E. J. Detgen has become vice president, home building products, Owens-Corning Fiberglas. T. V. Fowler is now vice president of sales to manufacturers; W. M. Keller, vice president, Fiberglas reinforced plastics; J. A. McKay, vice president, industrial and commercial construction materials; and S. J. Weinberg, Jr., vice president, Fiberglas textile fabrics. The new appointees will integrate marketing with product development and production.

Louis R. Kessler has been elected operations vice president for the company and William H. Curtiss, Jr. has been named vice president and director of marketing. John H. Thomas has become vice president and general manager of the Pacific Coast division and Ben E. Boyd has been appointed manufacturing vice president.

Mr. Kessler started with Owens-Illinois Glass Company in 1931 and joined Owens-Corning Fiberglas in 1946 as project engineer for the designing, construction and organization of the Fiberglas plant at Santa Clara, Calif. Upon completion of the plant he became vice president and general manager of the Pacific Coast division and was vice president and general manager of the general products division until his recent election.

Mr. Curtiss, vice president and general manager of the Pacific Coast division before his promotion, has served as administrative assistant to the president, advertising manager of the textile products division and general sales manager of the Pacific Coast division.

Mr. Thomas, one of the original management group who formed Owens-Corning Fiberglas, has devoted much of his career to basic research for fibrous glass and was head of the Owens-Illinois glass fibers laboratory in Newark, Ohio.

Mr. Boyd, who has served as plant superintendent and manager of the Newark plant, in addition to general factories manager, was previously vice president for manufacturing of the general products division.

Edward M. Everhard

Harold M. Alexander

Everhard in Charge of LOF Exports

Edward M. Everhard, vice president of Libbey-Owens-Ford Glass Company since 1953, will now devote his full attention to the LOF Export Company, of which he is president.

The export subsidiary has gained increasing importance with the development of direct shipping facilities via the St. Lawrence Seaway and the growing markets in Canada.

Mr. Everhard began his career at Libbey-Owens in 1926 as a workman in the window glass factory at Charleston, W. Va. and has since that time been western sales manager and general manager of distributor sales for the company.

Pyroceram Radome Contract to Corning

The first contract for full-scale production of Pyroceram radomes, which will be used on the Navy's Tartar missile, has been received by Corning Glass Works from Convair. The Pyroceram will be processed at the Corning, N.Y., plant by newly installed radome finishing machinery.

Corning Glass Works' Pyroceram radome, which will be used by Convair for the Navy's Tartar missile.

J. C. Swearengen

W. A. Seitz

Glass Container Promotes Two

J. C. Swearengen has been appointed manager of the Hayward, Calif., plant of Glass Container Corporation, and W. A. Seitz, manager of the Antioch, Calif., plant.

Mr. Swearengen, director of research and engineering, will establish a corporate engineering and research department at the company's Fullerton, Calif., operations.

Mr. Seitz has been appointed manager-northern plants and will be responsible for glass manufacturing operations at both plants in Antioch and Hayward.

Glass Bottle Blowers Ass'n.

A rise of five per cent in production of glass containers this year was forecast at the labor-management conference of the Glass Bottle Blowers Association. Nearly 21,000,000,000 bottles and jars were manufactured in the U.S. last year.

Corning Fills Two Executive Positions

Dr. Morton R. Shaw has been named supervisor of product development in the newly formed product development department at the Corning electronic components plant, Corning, N.Y.

Charles J. Lucy has become supervisor of product and applications engineering. His department will be responsible for creating new product designs and will also offer engineering services for customers.

Dr. Morton R. Shaw

Charles Lucy

1959

First Quarter Financial Reports

American-Saint Gobain

Net earnings were $108,765 as compared to $196,619 consolidated net loss for the same period in 1958. Net sales were $7,751,783 as compared to $5,356,039 for the same period in 1958.

Corning Glass Works

Net earnings were $5,756,754 as compared to $3,189,152 for the same period in 1958. Net sales were $43,108,268 compared to $36,976,719 for the same period in 1958.

General Refractories

Net earnings were $1,002,399 as compared to $187,994.59 for the same period in 1958. Net sales were $16,019,120.09 compared to $10,219,320.75 for the same period in 1958.

Knox Glass, Inc.

Net earnings were $267,514 as compared to $191,965 for the same period in 1958. Net sales were $9,270,780 compared to $8,319,209 for the same period in 1958. This ended Knox's second fiscal quarter.

Libbey-Owens-Ford

First quarter earnings (1959) are $17,152,379 as compared to $3,785,406 (1958).

Owens-Corning Fiberglas

Net earnings were $2,515,926 as compared to $1,892,985 for the same period in 1958. Net sales were $46,130,126 compared to $35,940,160 for the same period in 1958.

Owens-Illinois Glass Co.

First quarter earnings (1959) are $7,834,997 as compared to $6,566,417 (1958). Sales (1959) are $123,396,514 as compared to $119,323,820 (1958).

Pittsburgh Plate Glass Co.

Net earnings were $3,730,236 as compared to $5,068,336 for the same period in 1958. Net sales were $110,266,660 compared to $117,306,151 for the same period in 1958.

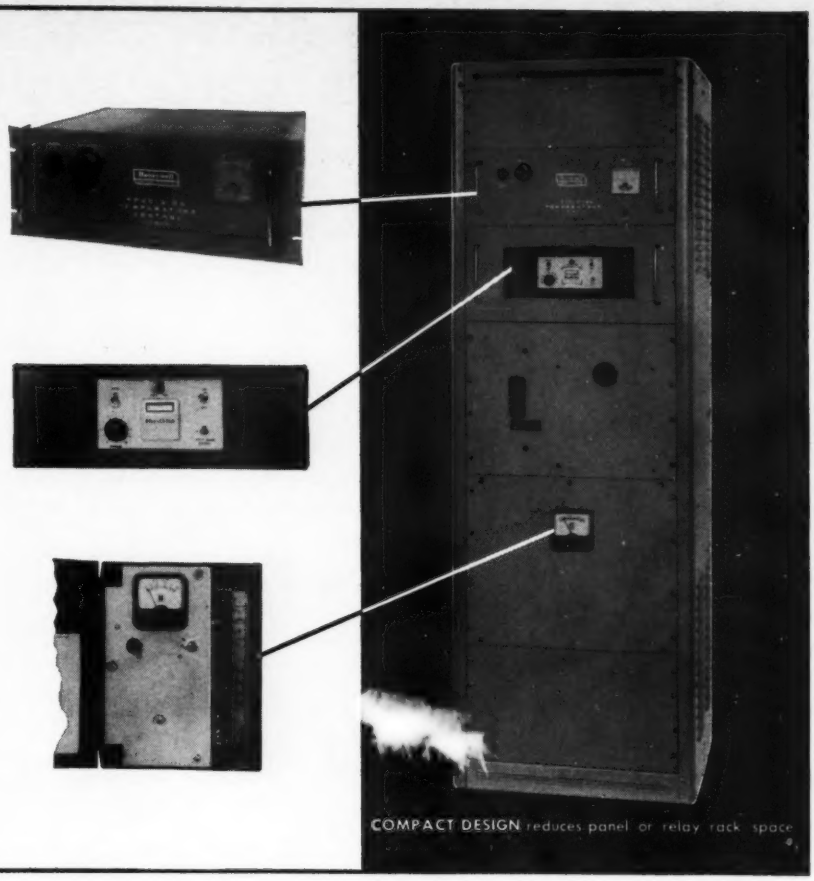
Thatcher Glass Co.

Net earnings were $430,585.87 as compared to $454,889.80 for the same period in 1958. Net sales were $9,631,713.62 compared to $9,105,815-.34 for the same period in 1958.

PRECISION TEMPERATURE CONTROLLER, Series 2HCT-3, has no moving parts. No stray electrical pickup . . . free from drift . . . continuous automatic standardization. Available in wide variety of ranges for any thermocouple input.

***ELECTR-O-VOLT* CURRENT OUTPUT PROPORTIONING CONTROL UNIT** has graduated proportional band dial, graduated reset rate dial, graduated approach rate dial, manual-automatic switch, manual control dial and power switch.

BROWN MAGNETIC AMPLIFIERS feature bias adjustment for full control rangeability, auxiliary control windings for feedback control systems, fused safety circuit, easily accessible terminal behind hinged door cover. The power input dial pointer is the only moving part. Two models available for loads up to 100 KVA.



COMPACT DESIGN reduces panel or relay rack space

Precision Package for Glass Fiber Bushing Control

. . . controls temperature within 0.25 degree at 2000°F

Combined in a single compact unit, this temperature controller, power proportioning control unit and magnetic amplifier give "right-on-the-nose" results with saturable core reactor furnaces whose temperature can be measured with thermocouples.

The Precision Temperature Controller consists of a null balance input circuit with manually adjusted set point and a highly stable d-c amplifier. The difference between the thermocouple signal and set point is amplified 100,000 times to provide the required sensitivity. Three-digit vernier set knob readable to one part in 2000 of a 1000°F. span.

The *Electr-O-Volt* power proportioning control unit provides a continuously variable control input to the Brown Magnetic Amplifier. It gives true non-interacting proportional-plus-reset, plus rate control action which adjusts heat input to compensate for the size of load, ambient temperature and other variations in heat demand.

The Brown Magnetic Amplifier receives its signal from the *Electr-O-Volt* unit and amplifies it for transmission to the control windings of the saturable core reactor . . . to provide stepless, contactless, highly accurate furnace control.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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First in Control

INVENTIONS AND INVENTORS

Annealing and Tempering

Method of annealing glass. Patent No. 2,871,624. Filed June 14, 1954. Issued February 3, 1959. No sheets of drawings; none reproduced. Assigned to American Optical Company by Lee O. Upton.

In the fabrication of certain glasses, for example, glasses of the arsenic sulphide type, it has been found that if the glass blanks are wrapped in metal, such as aluminum foil, placed in relatively intimate contact with the glass throughout the outer surface area thereof and then subjected to a controlled annealing cycle that very desirable and uniform results are obtained.

Satisfactory results have been obtained with an annealing cycle which comprises raising the temperature of the glass from room temperature gradually and continuously throughout a period of approximately 5 hours to a temperature of approximately 430°F. This is obtained by progressively increasing the temperature throughout the time cycle. The temperature of 430°F. is retained for a period of approximately 4 hours and the temperature is then reduced gradually and progressively from 430°F. to approximately 300°F. over a period of approximately 24 hours, and the furnace is then shut off to allow the glass to cool down from the 300°F. to room temperaure at its natural rate and with the furnace sealed. The 430°F. set forth above is the temperature at which the particular glass recited softens, and the 300°F. is a temperature below that of the strain point of the glass. With the present recited temperatures annealing may be accomplished in a much shorter period of time than would be required if the temperature was so controlled that annealing takes place substantially midway between the softening temperature and the strain point of the glass as has been usual with prior art annealing.

It has been found that with the above annealing cycle, annealing begins somewhere above the softening temperature of the glass and extends below the straining point thereof. After the blanks have been brought down to room temperature and the aluminum foil is removed, it has further been found that the foil does not stick to the glass and that impressions of the contact points of the aluminum foil with the glass are left in the surface thereof indicating that the glass had softened sufficiently to allow the impressions to remain.

There were 4 claims and the following references cited in this patent.

United States Patents

202,809, Gerike, Apr. 23, 1878; 210,731, Weyer, Dec. 10, 1878; 360,732, Sawyer, Apr. 5, 1887; 900,281, Holmes, Oct. 6, 1908; 2,609,301, Lindsey, Sept. 2, 1952; and 2,674,536, Fisher, Apr. 6, 1954.

Foreign Patents

996,809, France, Sept. 5, 1951 and 455,494, Germany, July 26, 1928.

Apparatus for cooling of glass. Patent No. 2,864,203. Filed October 13, 1953. Issued December 16, 1958. No sheets of drawings; none reproduced. Assigned to Compagnies Reunies des Glaces & Verres Speciaux du Nord de la France by Bernard Long.

The present invention relates to an apparatus for the rapid cooling of glass in the range in which its viscosity is between 10^{12} and 10^{14} poises, which range corresponds to a temperature zone including the critical annealing temperature zone.

In accordance with the invention, the walls of the chamber are highly absorptive in the radiation range in which the glass radiates the maximum of energy, and they are highly reflective in the range in which the glass radiates to a moderate or slight extent. Thus, the two major conditions necessary for carrying the invention into effect are realized:

1. Rapid cooling by means of the walls of the chamber only.
2. A smaller temperature gradient, throughout the thickness than in the case of a chamber having totally absorbing black walls, since the reflected energy is for the most part absorbed in the surface layer of the glass and raises the temperature of this layer and therefore tends to reduce the temperature difference between this layer and the central layer.

The walls of the chamber are made in two parts:

1. A mechanically strong case which is cooled on one surface and of which the other surface, turned towards the glass, has a high reflective power for infrared radiations.
2. A layer of small thickness applied to the reflecting surface of the case and having the selective absorption mentioned above.

The case is preferably made of metal. It may consist, for instance, of polished aluminum, of brass covered with a reflecting silver deposit, or of iron with a reflecting coating of chromium.

The absorbent layer is preferably a coating, a paint or a varnish containing an absorbent pigment.

It is advantageous to use finely ground clear or colored glass as the absorbent pigment.

The invention concerns a means for rapidly cooling glass employing only heat exchange by radiation and making it possible to create in the desired temperature range a temperature gradient, throughout the thickness, which is substantially smaller than that obtained when the glass is cooled by causing it to radiate on to the walls of a totally absorbing black chamber surrounding the glass.

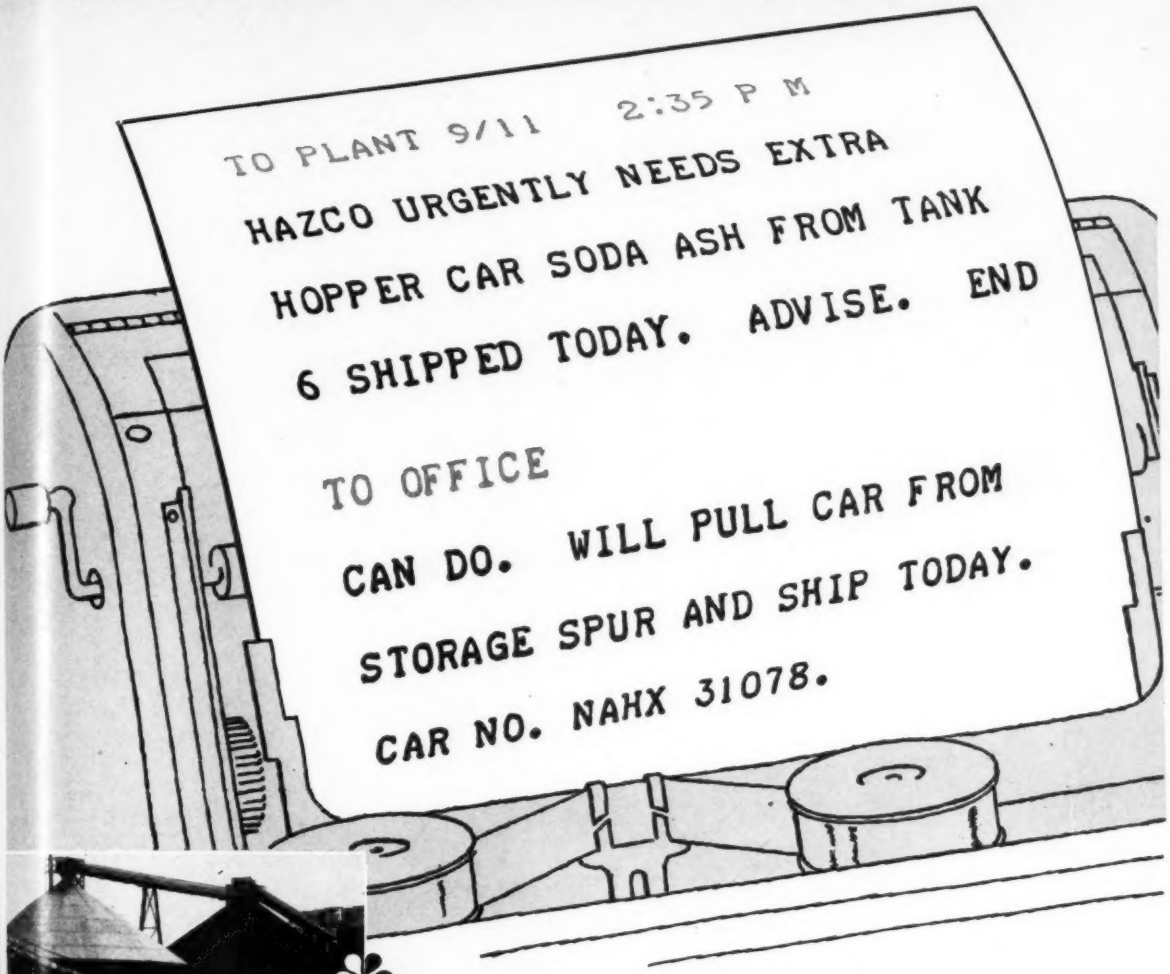
There were 5 claims and the following references cited in this patent.

United States Patents

1,865,811, Amsler, July 5, 1932; 1,895,548, Lebel, Jan. 31, 1933; 1,951,950, Rising, Mar. 20, 1934; 1,981,560, Littleton, Nov. 20, 1934; 2,122,941, Hufler et al., July 5, 1938; 2,365,967, Long, Dec. 26, 1944; 2,438,160,

(*Continued on page* 316)

West End "fills the order"...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HAZCO URGENTLY NEEDS EXTRA
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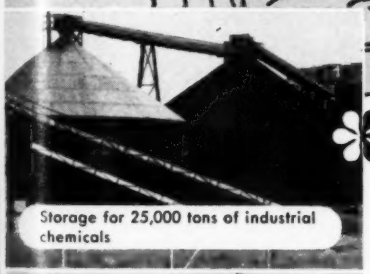
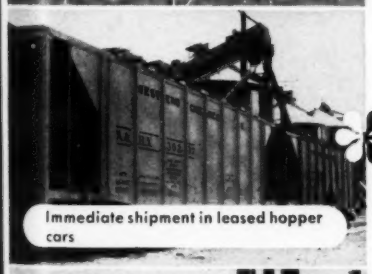
STORAGE SPUR AND SHIP TODAY.
CAR NO. NAHX 31078.


Storage for 25,000 tons of industrial chemicals


Immediate shipment in leased hopper cars

Vast natural source of raw material

Meeting service requirements to the letter and producing superior soda ash of consistently accurate particle size and chemical analysis are the essentials to which the West End organization is uniquely geared. A system of rapid communications linking our sales office in Oakland with our production, technical and shipping departments at the desert plant site permits each department head to have a complete understanding of the customer's individual requirements and to make firm commitments or provide the desired information promptly.

WEST END SODA ASH

WEST END CHEMICAL COMPANY

EXECUTIVE OFFICES, 1956 WEBSTER, OAKLAND 12, CALIF. • PLANT, WESTEND, CALIF.

DIVISION OF Stauffer CHEMICAL COMPANY

(*Continued from page* 314)

Green, Mar. 23, 1948; 2,482,698, Tillyer, Sept. 20, 1949; 2,553,945, Schrader, May 22, 1951; and 2,690,-078, Phillips, Sept. 28, 1954.

Other References

Infrared Production and Transmission Reflection and Measurement by Dr. Lewis R. Koller, "General Electric Review," Vol. 44, No. 3, March 1941, pages 167-173, inclusive.

Feeding and Forming

Method of making a glass seal. Fig. 1. Patent No. 2,813,-375. Filed August 16, 1955. Issued November 19, 1957. One sheet of drawings. Assigned to The Commonwealth Engineering Company by Alfred Lippman, Jr.

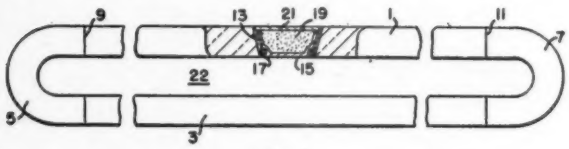


Fig. 1

This invention relates to seals and more particularly to seal structures for glass and to methods of producing the same.

It has been customary in the production of such multi-pane windows to secure a pair of spaced glass plates by a metal frame in which an organic sealing compound is incorporated for inhibiting the passage of moisture from the atmosphere to the dead air space. In such structure it is necessary to incorporate a silica gel or some other moisture absorbent to insure long life of the assembly.

Referring to Fig. 1, a port is shown formed in the glass plate *1* and is defined by a conical wall *13* in which there is positioned a cup-shaped insert *15*. The insert *15* is provided over a lower peripheral portion thereof with a compressible silicone rubber gasket *17* which compressibly engages the wall *13*. Securing these components of the seal structure together in intimately adhered relation and in air-impermeable fashion is a body *19* of a fusible inorganic salt superposed by a film *21* of a low melting glaze.

The inorganic salt may be any readily fusible material having a lower melting point than that of the glass body *1* and a higher melting point than that which occurs at normal atmospheric temperatures, which in the present case may be taken in the range of from –40°F. to + 130°F. For example, potassium or sodium nitrates are suitable, or the mixture of these compounds. A mixture of 54 per cent potassium nitrate and 46 per cent sodium nitrate, which melts at about 430°F., is eminently suitable for the practice of the invention.

The glaze *21* is preferably a low melting point borosilicate glass.

In forming the seal set out in Fig. *1* the metallic insert *15* together with the gasket *17* may be first compressibly placed within the port defined by the wall *13*; thereafter, the salt in fused condition is simply poured over the insert *15*, gasket *17*, and the wall *13*.

The fused salt flows rather readily and should be allowed to fill substantially the port. As the salt begins to set, but while still heated, the glaze *21*—in a molten condition—is applied in a thin film and allowed to set. As the temperature of the glaze will be somewhat higher than that of the salt, the upper surface of the setting salt will be refused and will blend with the applied glaze, assuring a firm adherence between these two components. The glaze will also adhere readily to the upper wall of the glass plate *1* which itself, to avoid strains, may be brought to a temperature between 200°F. and 300°F. in the area immediately adjacent to the port.

There were 6 claims and one reference cited in this patent.

United States Patent

2,720,009, Lippman, Oct. 11, 1955.

Furnaces

Method of, and tank furnace for, making glass. Fig. 1. Patent No. 2,808,446. Filed September 16, 1953. Issued October 1, 1957. One sheet of drawings. Assigned to Societe Anonyme des Manufactures des Glaces et Produits Chimiques de St. Gobain by Roger Emile Lambert.

Referring to Fig. 1, the liquid glass full of bubbles flows through the channel *b* into the fining zone and the channel is made so shallow that no back convection current occurs. The flow throughout the channel is in the direction of the outlet of the tank.

The glass in the fining zone *c* is heated by submerged horizontal electrodes *d*, two of which are shown, including one close to the inlet wall, while the other is near the outlet wall. Current supplied to the electrodes flows between them through the upper portion of the glass in the fining zone and heats this portion of the glass to the high temperature adapted to fining.

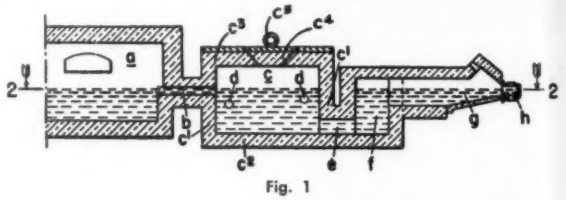


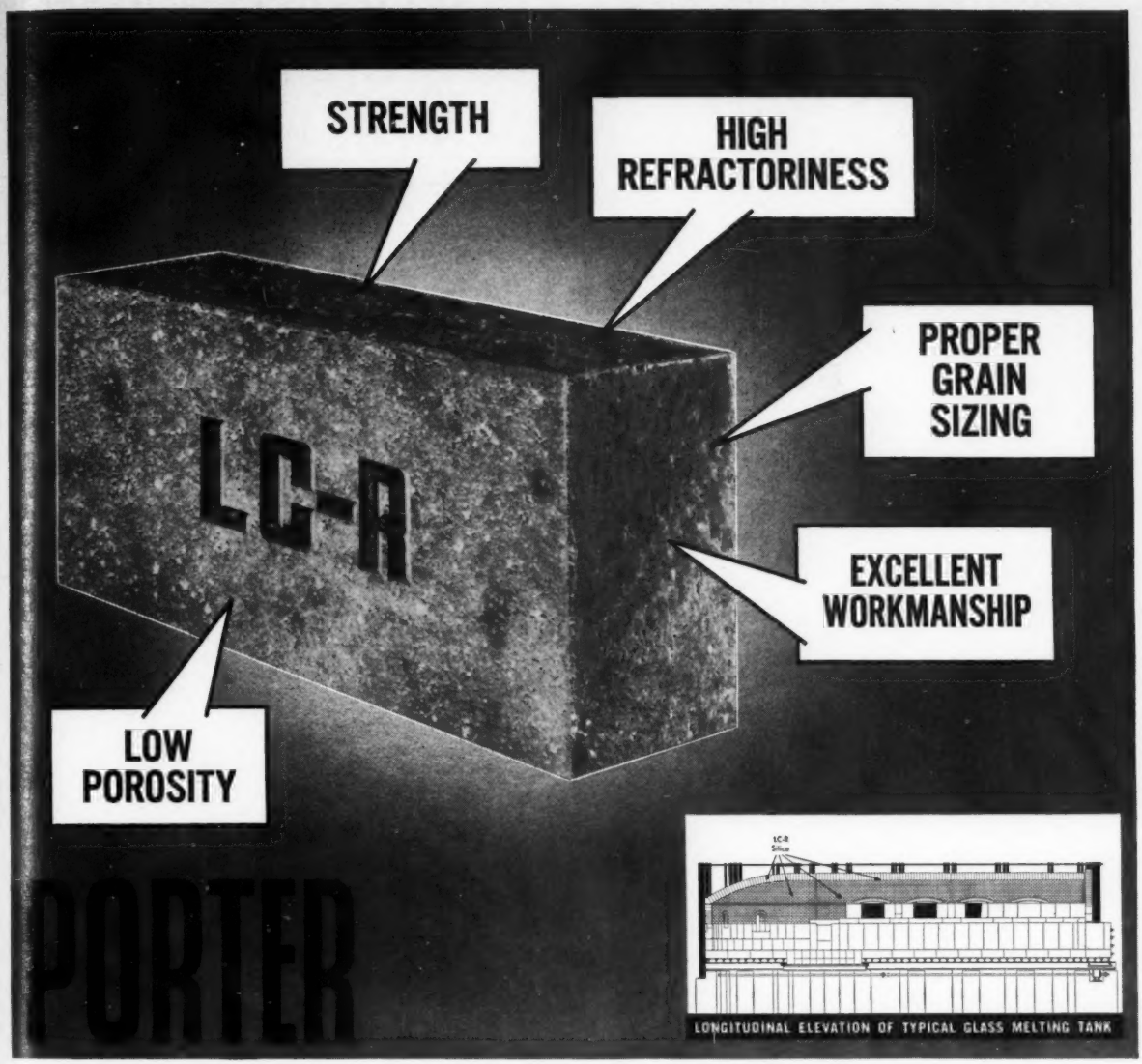
Fig. 1

Glass enters from the channel *b* into the immediate neighborhood of the electrode and is thus rapidly heated and, by reason of its lightness, remains in the upper portion of the glass until all bubbles in it have escaped and it becomes heavy enough to sink to the lower portion of the fining zone.

The unfined glass remains in the upper portion of the fining zone because it is lighter than the fined glass, firstly, by reason of its bubble content and, secondly, because the heating is localized in the upper part of the zone, with the result that the entering glass is at once raised to a high temperature.

By reason of the localization of the heating in the upper part of the fining zone, the temperature of the

(*Continued on page* 332)



brings you a super-duty **SILICA** brick for stronger, longer service tank crowns

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An Investigation of the Effect of Sand Grain Size on the Refining of a Pure Soda-lime Glass in a Laboratory Furnace

• THE WORK REPORTED BY M. Cable in the February, 1958, issue of *The Journal of the Society of Glass Technology* was undertaken to find the effect of sand grain size on the rate of refining of a simple soda-lime-silica glass. By following the variations with time of number of seed per cubic centimeter and the distribution of seed diameters, it was possible to compare the results with predictions based on the assumption that refining was effected by bubbles rising to the surface of the melt and bursting. The particular glass composition used was chosen, as were the sand grain sizes, because Preston & Turner (1940) had investigated the effect of temperature and sand grain size on the batch-free time of this glass. Their paper thus indicated the shortest founding times to be used while the longest were those at which the seediness had fallen to about $1/cm^3$. In the present work melting was done in an electrically heated furnace and the technique of both melting and seed counting was very similar to that used by Bastick (1956).

Sixty-gram melts of glass, of composition (weight per cent) 73.5, SiO_2; 10.0, CaO; and 16.5, Na_2O were founded for varying times at 1400°C using four different sand grain sizes from 0.34 to 0.095 mm. Discs were cast from the melts and measurements of the total number of seed and their size distribution made on photographic enlargements of the annealed discs. The results showed that the total number of seed decreased exponentially with time. As the sand grain size decreased the seediness at the batch-free time increased, but the rate of refining also increased, and the most homogeneous and least seedy glass was produced most quickly by using the finest sand.

The data enabled the rates of disappearance of particular sizes of seed to be derived and again the relation between number and time was exponential. The refining was therefore not controlled by the rise of bubbles through the melt. Relatively rapid convection currents were shown to exist in the melt but later work showed that the elimination of convection did not affect the refining. It was concluded that the exponential relation was not due to convection but to some other process that caused small seed to disappear much more rapidly than predicted from Stokes' law. The size of sand grains used affected the rate of disappearance of a particular size of bubble as well as the number and size distribution at the batch-free time. The results for the series using the finest sand showed an anomaly that could not be accounted for solely by the change in homogeneity of the melts.

The following properties of importance are influenced by the size of sand grains used in the melting of glass:

1. batch-free time.
2. homogeneity of the melt.
3. seediness at the batch-free time.
4. size distribution of seed at the batch-free time.
5. rate of refining of a particular size of seed.

Preston & Turner (1940) found that the batch-free time depended directly on the size of sand grain; that is, on the surface area of silica exposed. They also observed that only about one tenth of the batch-free time was occupied by vigorous reaction and the rest by solution of the remaining sand grains. Since the solution of these grains in the melt must produce silica-rich cords there is obviously an advantage in using finely divided silica. A continuous improvement in homogeneity was found as the sand grain size decreased and the improvement was most marked between the two finest fractions.

The seediness at the batch-free time and the distribution of seed diameters depend on several factors that have not yet been investigated. The processes that determine these two properties are those operating during the initial reaction of the batch. That the number of seed should increase as the surface of silica exposed for reaction increases is reasonable, as is the fact that more large seed were formed as the initial reaction became more rapid and the gas was evolved more quickly.

The homogeneity of the melt determines its effective viscosity and equilibrium gas content, while the rate of reaction may influence the quantity of gas retained. It is therefore not surprising that the sand grain size affected the rate at which a particular size of bubble disappeared.

Decreasing the sand grain size increased the number of seed formed but shortened the batch-free time, increased the rate at which a particular size of bubble disappeared (except for the anomalous results for 0.095 mm sand), increased the average size of seed, and so the rate of refining, and also improved the homogeneity of the melt. As a result well-refined and homogeneous glass was produced most quickly by using the finest sand.

Most workers who have studied either melting or refining have considered them as two separate processes, and this division is a natural one to make because of obvious differences in the processes and in the experimental methods used. However, the work reported here has clearly shown that this division is an artificial one: refining cannot be fully understood without studying the reactions resulting in the formation of the melt.

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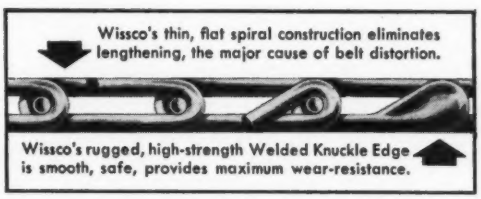
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Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during March, 1959, was as follows: *Flat Glass*: a preliminary figure of 29,500 for March, 1959, indicates an increase of 4.6 percent over the adjusted figure of 20,500 reported for February, 1959. *Glass and Glassware, Pressed and Blown*: an increase of .21 per cent is shown by the preliminary figure of 82,000 reported for March, 1959, when compared with the adjusted figure of 80,300 reported for February, 1959. *Glass Products Made of Purchased Glass*: the preliminary figure of 15,200 given for March, 1959 is an increase of 4.1 per cent over the adjusted figure of 14,600 reported for February, 1959.

Payrolls in the glass industry during March, 1959, were as follows: *Flat Glass*: An increase of 1.0 per cent is shown in the preliminary $13,659,000 given for March, 1959, when compared with February's adjusted $13,520,000. *Glass and Glassware, Pressed and Blown*: An increase of 0.13 per cent is shown in the preliminary $8,902,000 reported for March, 1959, when compared with the previous month's adjusted $8,782,000. *Glass Products Made of Purchased Glass*: a preliminary figure of $7,171,000 was reported for March, 1959. This is a decrease of .4 per cent when compared with the adjusted figure of $7,174,000 for February, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	April, 1959
Food	1,240,000
Medicinal and Health Supplies	1,370,000
Chemical, Household and Industrial	1,024,000
Toiletries and Cosmetics	829,000
Beverage, Returnable	983,000
Beverage, Non-returnable	136,000
Beer, Returnable	432,000
Beer, Non-returnable	896,000
Liquor	820,000
Wine	402,000
Sub-total (Narrow)	8,132,000

Wide Mouth Containers

Food	*3,248,000
Medicinal and Health Supplies	394,000
Chemical, Household and Industrial	154,000
Toiletries and Cosmetics	289,000
Packers' Tumblers	23,000
Dairy Products	144,000
Sub-total (Wide)	*4,252,000
Total Domestic	12,384,000
Export Shipments	222,000
TOTAL SHIPMENTS	12,606,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production April 1959	Stocks April 1959
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,757,000	6,630,000
	Wide Mouth	*4,607,000	*6,713,000
Beverage, Returnable		1,094,000	2,140,000
Beverage, Non-returnable		107,000	215,000
Beer, Returnable		385,000	614,000
Beer, Non-returnable		882,000	996,000
Liquor		812,000	1,351,000
Wine		402,000	765,000
Packers' Tumblers		31,000	98,000
Dairy Products		149,000	343,000
TOTAL		*13,226,000	*19,943,000

*This figure includes Fruit Jars and Jelly Glasses.

Glass container production: production based on figures released by the Bureau of the Census, Industry Division, was 13,226,000 gross during April, 1959. This is an increase of 5.6 per cent over the previous month's production figure of 12,518,000 gross. During April, 1958, glass container production was 11,091,000 gross, or 16.1 per cent under the April, 1959, figure. At the end of the first four months of 1959, glass container manufacturers have produced a preliminary total of 48,664,000 gross. This is 6.4 per cent more than the 45,725,000 gross produced during the same period in 1958.

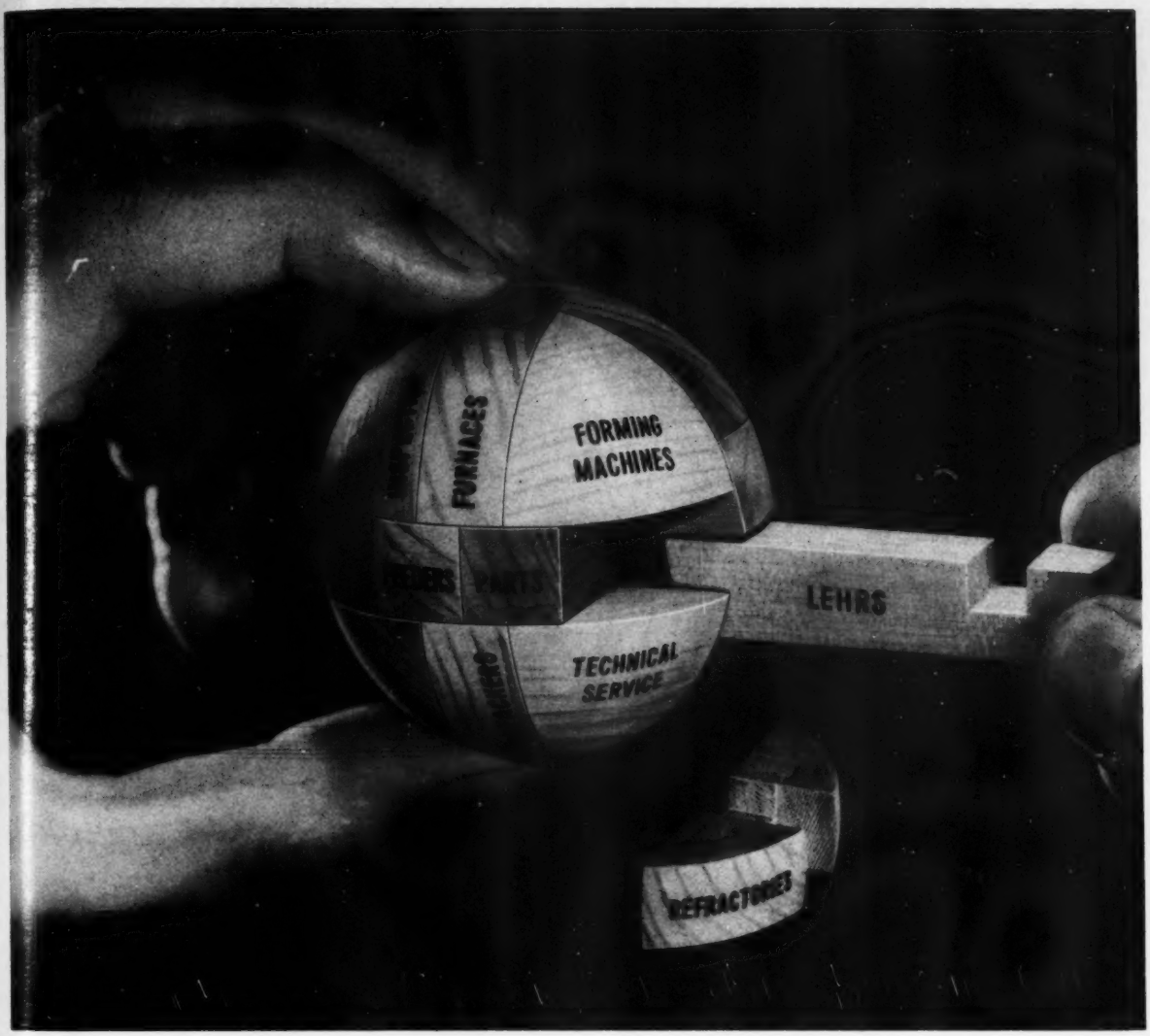
Shipments of glass containers during April, 1959, came to 12,606,000 gross, an increase of 3.9 per cent over March, 1959, which totaled 12,125,000 gross. Shipments during April, 1958, amounted to 11,066,000 gross, or 12.2 per cent less than April, 1959. At the end of the first four months of 1959, shipments have reached a preliminary total of 46,450,000 gross, which is 6.1 per cent more than the 48,772,000 gross shipped during the same period the previous year.

Stocks on hand at the end of April, 1959, came to 19,943,000 gross. This is 3.1 per cent more than the 19,341,000 gross on hand at the end of March, 1959, and 4.7 per cent more than the 19,031,000 gross on hand at the end of April, 1958.

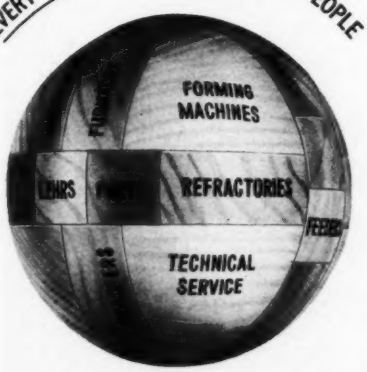
ACS PACIFIC COAST MEETING

The American Ceramic Society will hold its twelfth Pacific Coast Regional Meeting at the Benjamin Franklin Hotel in Seattle, Wash., on October 15, 16, and 17.

Authors submitting manuscripts must send them with the titles and abstracts to the papers chairman, Rudy Corwin, Applied Physics Laboratory, 1013 East 40th St., Seattle 5, Washington. Authors are requested to have their papers pre-printed for distribution at the meeting; if they would prefer the local section to duplicate them, these manuscripts must be received by the section before August 15, 1959. The deadline for titles and abstracts is June 25, 1959.



EVERYTHING FOR GLASS BY GLASS PEOPLE



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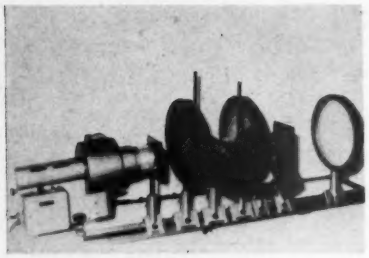


Optical Stress Bench

Dr. Heinrich Schneider, Optotechmsche Fabrik, Bad Kreuznach, West Germany, has a new optical stress bench which is said to be useful in the following areas:

1. Research on stresses produced by pressure or tension in transparent mechanical models.
2. Examination of worked glass for internal stresses and strains owing to external forces.
3. Determination of the index of refraction of transparent materials.

Low-voltage Amplifier

Hagan Chemicals & Controls, Inc., Pittsburgh, Penna., has an ultra-sensitive electronic low-voltage linear amplifier which is designed to increase the speed and accuracy of low-level DC voltage measurements. The amplifier can develop full electrical output in less than 0.1 second and is said to be completely compatible with inputs from thermocouples, radiation pyrometers, thermal converters and DC strain gages.

Applications include temperature measurement and control, telemetering, stress measurement and automation.

Steam-Jet Cleaner

Pantex Manufacturing Corp., Pawtucket, Rhode Island, has a new portable, oil-fired steam-jet cleaner. It is completely enclosed with built-in soap tank and controls. Automatically controlled cleaning pressures from 50 to 150 psi can be obtained in 90 seconds.

Ceramic Grade Rutile

Metal & Thermit Corp., Rahway, N.J., has a new ceramic grade milled Virginia rutile for the production of porcelain enamel frits in making special glasses, including fiber glass and glass enamels.

Microscope Camera

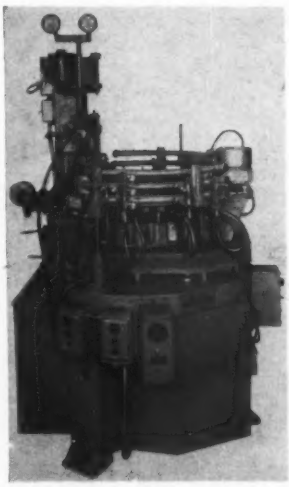
Philips Electronics, Inc., Mount Vernon, N.Y., has a new plate camera which has been designed specifically for use with the Norelco EM-75 electron microscope. The distance between photographic plate and screen is such that the ratio of enlargements is 1 to 1. Binoculars with seven times magnification are hinge-mounted on the window and can be used or turned away, for the operator's convenience.

Epoxy Resin For TV Tubes

The Dow Chemical Co., Midland, Michigan, has developed an epoxy resin system to laminate safety panels directly to the face of television picture tubes. These laminated tubes are said to provide a high safety protection to the viewer, as well as a sharper image on the screen.

Glass Diode Machine

Kahle Engineering Co., Union City, N.J., has introduced a new automatic two-purpose glass diode body case machine with a capacity of up to 1500 glass body cases per hour. The unit may be used on larger automated production lines to make beaded lead wires alone, or it may be used to produce entire glass body cases. This is possible because the machine first produces a beaded lead wire and then seals a glass body sleeve over it.

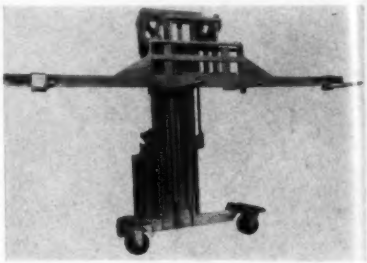


Flowmeter

General Electric, Schenectady, N.Y., has developed a "true mass" flowmeter which, the company reports, precisely measures the weight of flowing fluids (directly in pounds) with high accuracy over wide ranges of flow rate, pressure, temperature and density. First production units—expected to be ready early in 1960—will meter such industrial fluids as refinery and natural gas, oxygen and nitrogen. Later on, the flowmeter will be adapted to the measurement of light gases such as hydrogen, and helium as well as high-temperature, corrosive and cryogenic fluids.

Narrow-Aisle Fork Truck

The Raymond Corp., Greene, N.Y., has designed a fork truck carriage extension for use with narrow-aisle trucks for simplifying the handling of long, springy items like diameter tube stock.

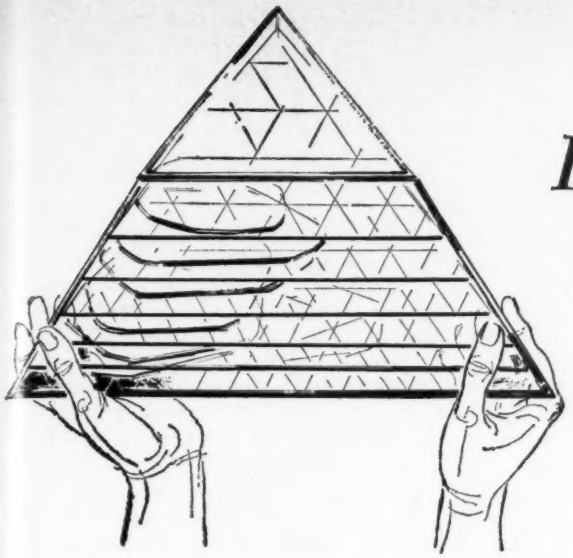


CATALOGUES RECEIVED

Vibrating screen separator. (2 pages) Specifications and blueprint diagrams of separator which may be used for grading bulk materials such as potash, perlite and silica.
DE LAVAL SEPARATOR COMPANY, Poughkeepsie, N.Y.

Spray coatings. (18 pages) Describes vacuum metalizing spray coatings for use in conjunction with metallizing thermoplastics, thermosetting plastics, metals and glass.
BEE CHEMICAL CO., Chicago, Ill.

Vibrating screens. (48 pages) Describes 12 different types in 212 sizes, including tables of materials, selection data, drawings and cut-away photographs showing construction features.
LINK-BELT CO., Chicago, Ill.



Effect of Lithium's High Ionic Potential on Glass Making

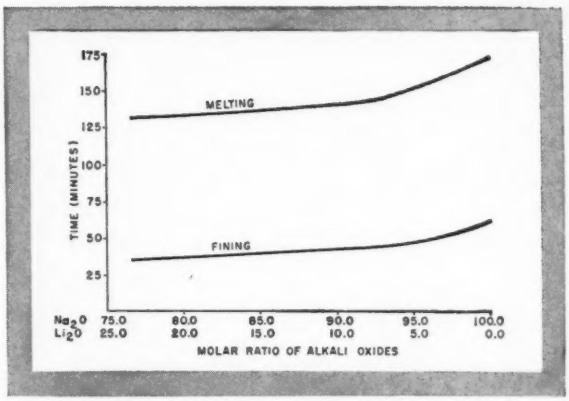
When Zachariesen proposed his rule for the behavior of ions in glass compositions, he didn't *have to* account for the confusing behavior of lithium. Too little was known about its behavior.

Reasoning from geometrical considerations and matters of electrical balance, he neatly accounted for the consistent behavior of such large, weakly charged alkali ions as sodium and potassium as network modifiers, and such small, heavily charged ions as boron and silicon as network formers.

But where should lithium be placed? Call it a typical alkali network modifying ion and you find it well nigh impossible to explain its behavior in such systems as the phosphate glasses. For though lithium is traditionally an alkali metal, it has the improbable ionic radius of 0.6Å—a high ionic potential of 2.78—and fourfold coordination.

Many of the strong influences exerted by small additions of lithia on glass properties can be traced to this triad. Substituted molecularly for soda (ionic potential 1.1), lithia should distort silicon-oxygen bonds to the extent of reducing softening point, anneal point, and strain point. And recent research tends to support this assumption. It has been found experimentally that lithia, by influencing the viscosity of silica melts and the rigidity of silicate structures, appreciably reduces melting and fining time.

Few of even the most modern theories of glass structure account for the confusing behavior of the lithium ion. More information is certainly needed. As a supplier of lithium chemicals and glass grade lithium minerals to the glass industry, we are doing everything we can to develop data through a continuing exploration of lithium glass forming systems.



Effect of Lithia on the melting and fining times of a window glass

The fruits of this research program and our years of practical experience can be brought to bear on your problem. We'll gladly arrange discussions with our engineers. Write Foote Mineral Company, 477 Eighteen West Chelten Building, Philadelphia 44, Pennsylvania.

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NEW BOOKS

Silicones, by *Robert N. Meals*, manager, chemicals and chemical process unit, and *Frederick M. Lewis*, manager advance development, both of Silicone Products Dept., General Electric Company. 304 pages (1959). $5.95.

This work is aimed at design engineers, formulators, and manufacturers in all industries who might have interest in silicones as engineering and raw materials. The book's scope includes the manufacture, properties and applications of the silicones, with data on the properties of silicone resins, fluids, and rubbers at high temperatures. Case histories are given of present industrial applications, and many new ones. These include the uses of silicones as chemicals, rubbers, resins, fluids, greases, adhesives, sealants, surface coatings and many others.

Publications by National Bureau of Standards

Standard Materials Issued by the National Bureau of Standards, National Bureau of Standards Circular 552, Third Edition, 27 pages (1959). 35 cents. Order from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

This circular lists the standard materials issued by the Bureau and their prices. Information on certified compositions and properties and purchase procedures are given. When these materials were first issued by the Bureau, they were known as Standard Samples, since they were used as standards in chemical analysis. The term was extended to similar composition standards and later to materials certified with respect to chemical purity or to some physical or chemical property. The term has grown to include certain reference materials issued without certification of composition or properties.

About 250 of over 500 standards now issued by the Bureau are of certified chemical composition; some 100 of these have been prepared specifically for use in spectroscopic analysis. Other standard materials include those certified for such properties as acidity (pH), viscosity, melting point, density, index of refraction, and heat of combustion. Recently a number of radioactive materials, uranium isotopes, lithium ores, aluminum refractories, and phosphor materials were added.

NBS standard materials are used principally for checking analytical methods; standardizing solutions for volumetric analysis; developing new or improved methods of analysis; and calibrating and standardizing spectrometers, spectrographs, colorimeters, ph meters, Geiger counters, scintillators, ionization chambers, pyrometers, polarimeters, refractometers, viscometers and other laboratory and plant instruments.

The Journal of Research, National Bureau of Standards. In four sections. Separately available. July 1, 1959. Order all publications from the Superintendent of Documents U.S. Government Printing Office, Washington 25, D.C. The Journal reports the research and development in physics, mathematics, chemistry and engineering.

These papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

A. *Physics and Chemistry*. Issued six times a year. Annual subscription: Domestic $4.00; Foreign, $4.75. The major emphasis is on standards of physical measurement, fundamental constants, and properties of matter.

B. *Mathematics and Mathematical Physics*. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.
Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems.

C. *Engineering and Instrumentation*. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. Also work in acoustics, applied mechanics, building research, and cryogenic engineering.

D. *Radio Propagation*. Issued six times a year. Annual subscription: Domestic, $4.00; foreign, $4.75.
Includes propagation in ionized media, scattering by turbulence, effect of irregular terrain on propagation, diffraction and scattering by solid obstacles, propagation through time-varying media, surface waves, and antennas.

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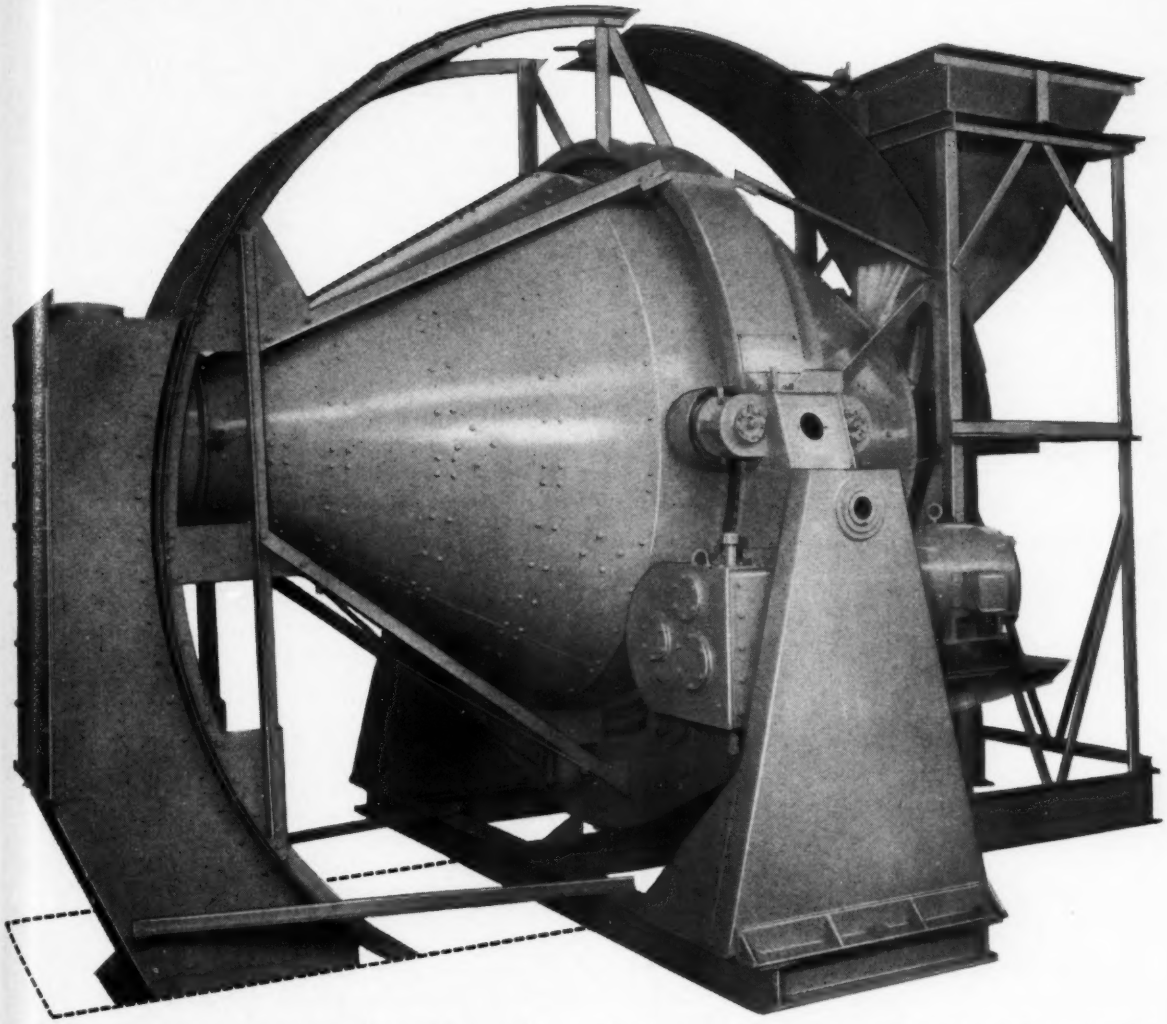

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AB-4081

Devitrification and Thermal History

(*Continued from page* 307)

strates an essentially linear relationship between crystal size and heating time.

To compare the sizes of the crystals formed at 700°C. in previously unheated glass with those in the glass given a 900°C. thermal history of an hour, we have the data plotted in Fig. 2. It appears from this diagram that the one-hour treatment at 900°C. has delayed the crystal growth to such an extent that six times as much time is needed for devitrification as with the glass not previously heated. The conclusion is that glasses with thermal history (above the liquidus) are more resistant toward devitrification.

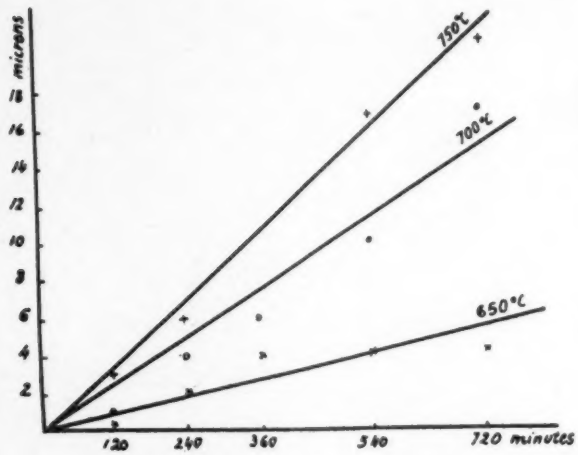


Fig. 2. Crystal size vs. time with, and without, previous heat treatment.

From the data in Table I, we can calculate the rate of crystal growth at the different temperatures. The values thus obtained are shown in Table 2. Using mean values, and correlating them with corresponding values for the untreated glass, we get the data summarized in Table 3. It thus becomes evident that previous heating of the glass above its liquidus for one hour has reduced the rate of crystal growth by 88 per cent at 650° and 700°C., and by 74 per cent at 750°C.

On the surface of the glass specimen which had been previously heated for 5 hours at 900°C., the first visible crystals appeared only after 240 minutes and did not appreciably grow during the following 480 minutes. The length of the few acicular crystals was estimated between 0.5 and 1.0 micron.

In the author's opinion, the retardation of devitrification by the heat treatment described can be accounted for by stabilization of the glassy liquid.

As I have earlier explained, the crystalline grains of certain raw materials, notably sand, have not sufficient opportunity to change their structures into irregular, unsymmetrical, random networks, and islands of the original lattice structure remain unaltered. These islands act as nuclei, and oriented lattices unite. The longer the previous heat treatment at high temperatures, the fewer the islands of residual lattice structure that can persist in the melt and the smaller their size. The pre-heating above the liquidus operates in this manner; hence, the transformation, growth, and eventual appearance of visible crystals require more time.

Table 2

Rate of crystal growth of magnesia glass with thermal history

	Micron Per Minute					
	30 Minutes	*60 Minutes*	*120 Minutes*	*180 Minutes*	*270 Minutes*	*360 Minutes*
650°C	—	0.003	0.010	0.011	0.007	0.006
700°C	—	0.008	0.017	0.017	0.018	0.024
750°C	—	0.025	0.025	0.036	0.031	0.020

Table 3

Comparison of the rate of crystal growth of heat-treated and heat-untreated magnesia glass

Temperature of crystallization	**Rate of crystal growth micron per minute**	
	Heat-treated	*Heat-untreated*
650°C	0.050	0.006
700°C	0.140	0.014
750°C	0.105	0.031

Lava Glass

(*Continued from page* 296)

outlined in the published course of experiments by the great French chemist and statesman, Jean Antoine Chaptal, Count de Chanteloup (1756-1832).

More than one French glass works thereafter made substantial use of Chaptal's discoveries. In 1780 a French bottle manufacturer named Ducros, following the suggestions of Chaptal, used basaltic earth (volcanic ash) and lava in his melts. He produced a good metal, well suited at that time for bottles.

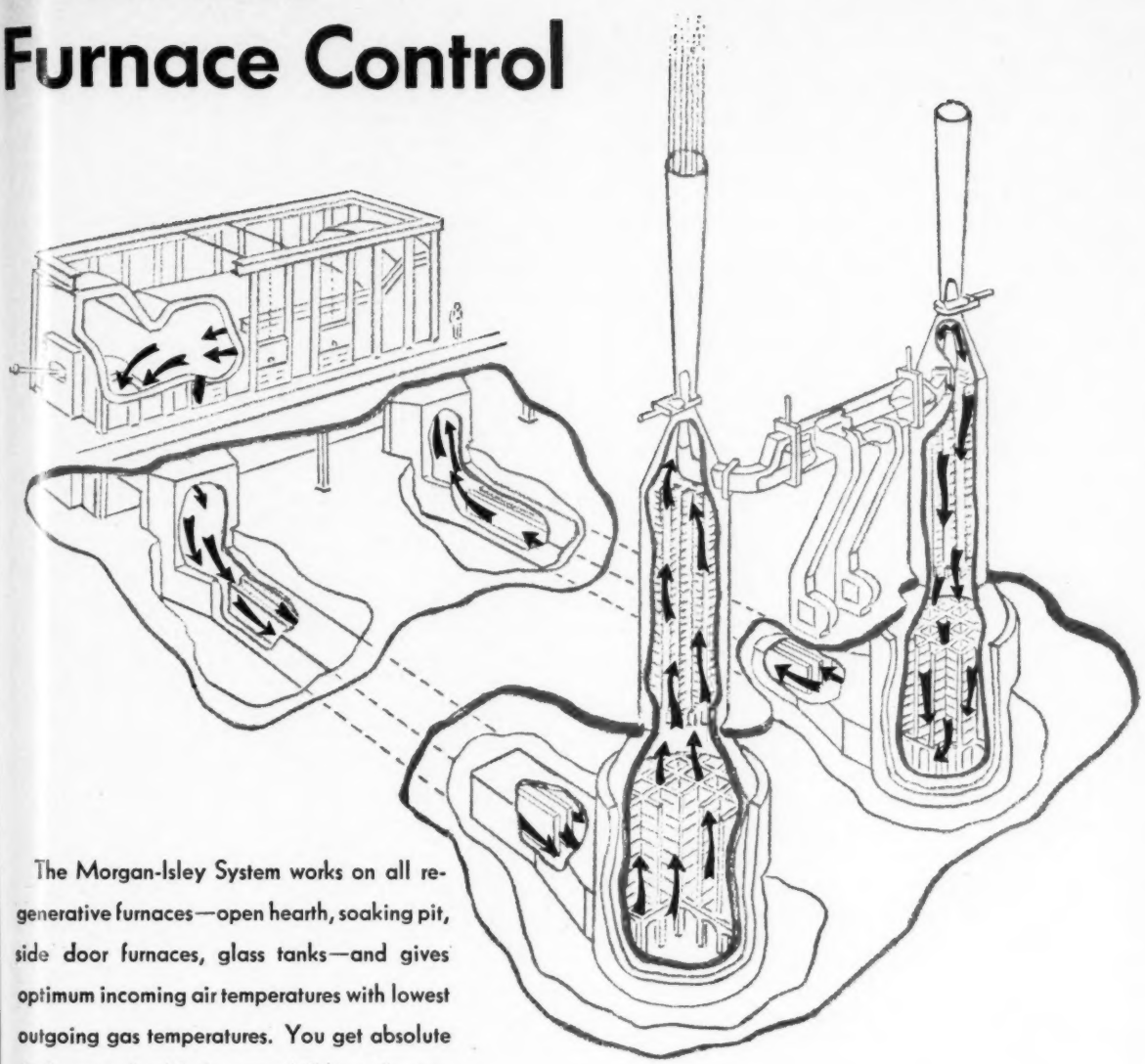
In his first trial with this earth, Ducros fused it in a glass pot without admixture of any other substance. He obtained a lustrous glass of an exceedingly deep yellow color. In subsequent experiments various proportions of sand were used in conjunction with the basaltic earth. The mixture which Ducros found best for his purposes was made with equal parts of each ingredient. This produced glass of an olive green color.

For a time there was considerable demand for Ducros' lava glass bottles; however, owing to a difficulty which the manufacturer experienced in procuring materials having the requisite uniformity in their constituent parts, the manufacture was, after a time, abandoned.

The well-known glass manufacturer Giral produced black bottles from a melt composed simply of three parts lava and one part river sand. Giral also made beautiful glass articles out of a melt of pure lava, without any alloy or admixture of any kind. Among the articles produced by Giral were stoves, tables, mantle pieces, tiles for flooring, and many other decorative and useful items.

Soon after Ducros' experiments the French chemist Alliot made trials with lava glasses producing several interesting color effects. Not having recourse to the furnace of a glass-house, Alliot was obliged to content

Absolute Furnace Control



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himself with the less intense heat of a potter's kiln, wherein the different mixtures which he employed were severally heated during eighteen hours.

The experiments were all conducted in crucibles, and it is probable that the results he obtained would have proved more satisfactory if he could have had a more efficient mode of heating.

Alliot's report of his findings were as follows:

No. 1 was filled with pure basaltic earth. This in fusing was converted into a black glass, which was opaque, and tolerably well melted.

No. 2 contained a mixture composed in equal parts of basalt, ashes, and white quartz in powder. This produced a coffee-colored glass, which was lustrous, and somewhat resembeled porcelain in appearance.

No. 3 was charged with half basalt and half common sand. The glass produced from this compound appeared, when in the mass, of a blue-black color; but when small thin portions were examined, these proved of a yellowish green. This glass was tolerably well melted.

No. 4 consisted of one third each basaltic earth, sand, and refuse soda. The result was a transparent glass of a greenish-yellow color, and of good quality; it was very smooth and shining, well melted, and would have formed excellent bottles.

No. 5 consisted wholly of sand taken from the river Orb, in the immediate neighborhood of which there is found a considerable quantity of basaltic earth. The glass from this sand was well melted, and appeared to be every way adapted for the manufacture of very good and serviceable glass bottles.

Basaltic earth is exceedingly well qualified both for fusion by itself, and for employment as a fluxing material where other substances are used. By analysis, it is found to contain about 45 parts of silex; 16 of alumina; 20 of oxide of iron; 9 of lime; and from 2½ to 4 parts of pure soda. Three of these substances are very powerful fluxes.

Some other minerals were proposed by manufacturers of lava glass bottles, on account of the soda they contained, as being well qualified for making glass; for instance, klingstein, which contains nearly one twelfth part by weight of that alkali. Because other fluxing materials present in basaltic earth were wanting in those other minerals, however, they proved far less fusible.

Early producers of lava glassware found that whenever basaltic earth was largely employed in the composition of glass, it usually proved to be dark olive green color, varying sometimes to a very deep yellow. It did not appear at all probable that this color could in any material degree be corrected. The glass produced was specifically lighter than any common green bottle glass; and at the same time was considerably harder and tougher, so as to bear, without injury, blows which would infallibly have broken ordinary glass. The quantity of alkali which it contained was small—much smaller, in fact, than was required to bring glass of every other description, then made, to a workable state. For this reason basaltic glass was peculiarly well qualified, in its time, for chemical glassware; as vessels made with it were able to resist the destructive action of corrosive liquids.

In later experiments Alliot made trials of various other combinations of basaltic earth; with the production of bottle glass as his aim.

The first was a mixture of equal parts of ashes and a volcanic granite. This fused perfectly, and produced a very fine, dark and lustrous glass, exceedingly well qualified for the composition of bottles. The second was composed of 1 part ordinary soda, 12 parts ashes, and 6 parts common sand. The glass thus formed was of a yellowish black, interspersed with veins of bluish white, which were opaque.

At Goettingen, in 1811, Johann Heinrich Moritz Poppe published a report in Gesichte der Kuenste und Wissenschaften, concerning the lava glass experiments made by le Sage, Chaptal, Giral and the Englishman, Sir James Hall. Poppe also reported that in Bohemia, "already for more than a few years," glass utensils chiefly boxes, candle sticks, and such wares, were manufactured out of a blackish basalt glass. He also informed glass manufacturers that, because of the fluidity of the basalt melt, it should not be blown as an ordinary glass mass; and, that the metal would not lend itself well to cutting and polishing.

About 1884 Sowerby, of Newcastle-upon-Tyne, made a type of lava glassware utilizing the blast furnace slag to which was added cryolite. Sowerby's called this ware "vitro porcelain." The glass was a streaky green with purple veins of opaque quality running throughout the metal. They also produced other color effects similar to Challinor, Taylor & Company's "Mosaic" glassware in an opaque glass simulating marble or agate stones and in "jet" black. On May 26th, 1893, Count Solms-Baruth of Klitschdorf, Silesia, patented a method for producing glassware resembling agate. The patent papers were quite specific and we quote them here:

"The process is carried out practically in the following manner:—

100 parts of basalt
50 parts of soda
10 parts of borax
20 parts of carbonate of lime
80 parts of sand
1 part of chloride of silver.

"These ingredients are finely pulverized and intimately mixed, and are placed in a powdered state in a glass furnace, heated to a very high temperature; that is to say, they are placed in the melting pots of the same.

"Instead of basalt, lava or slag from glass or welding furnaces, or iron ore, or solid residues of burnt pyrites, may be used.

"After the mixture has been thoroughly converted into glass, which is accomplished after a lapse of about six hours, 20 parts of basalt are gradually introduced in pieces of the size of a hazel nut, or thereabouts; this last operation taking about two hours. The whole glass mass is now stirred diligently with an iron bar, while three parts of dichloride of tin is added to the mixture. After this is done, the molten glass mass is left for two or three hours, and subjected to the process of purification, when it is ready for working."

Count Solms-Baruth suggested that the glass made from this melt be cooled irregularly thereby making the more quickly cooled parts appear darkest. The incomplete dissolution of the basalt, lava, or slag from glass

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or welding furnaces, produced a turbidity throughout the metal creating effects resembling agate stones. By using other metallic salts as fluxes, the color was varied; for instance, copper suboxide and tin monoxide gave a red or black color against which the splotches of variegated color showed to advantage.

We should mention that in 1875 S. Troutmann & Company of Philadelphia, agents for A. Tschinkel of Bohemia, offered the trade a lava pottery known as "Sydrolite." Troutmann was also the sole agent for the Phoenix Pottery Company, a subsidiary of Schreiber & Company, who were domestic manufacturers of lava pottery. Messrs. John B. Connally Company of New York City also produced a "lava pottery with a vitrified surface," according to their advertisements in the trade journals. The Mettlach factory in Germany produced a type of lava pottery too. The basalt and stonewares of Josiah Wedgwood were a form of lava pottery, and these black wares, agate and granite wares, influenced the designs and decorations Shirley used for his interesting Sicilian Ware.

Gold Films

(*Continued from page* 306)

pends upon the concentration of the gold chloride solution and the amount of reducing agent (hydrogen peroxide) is used.

Instead of a pretreated glass using a gold solution, Herrmann recommends the glass be pretreated with a film of silver from a Rochelle solution, or a silvered glass containing a lead compound. The silvered surface must of necessity be sufficiently thin to transmitted light.

REFERENCES

This portion of the present manuscript reviews in alphabetical order the names of those investigators and inventors whose names are mentioned in the text. If additional information is required, the original source from which the present text is prepared, should be consulted.

Andres, F. O., U. S. Pat. #1,281,262 Oct. 15, 1915; U. S. Pat. #1,953,330 Apr. 3, 1934.

Anonymous[1], Indust. Eng. Chem., Vol. 31, p. 5, 1939.

Anonymous[2], Office of Technical Service, Department of Commerce, PB-101,339, p. 11, 1950.

Anonymous[3], Nature, Vol. 170, p. 236, 1952.

Aufsberg, C., German Pat. #178,525, Sept. 5, 1905.

Averkieff, N., Zeit. Anorg. Allgem. Chem., Vol. 35, p. 329, 1903.

Barnes, A., British Pat. #9977, Apr. 30, 1898; U. S. Pat. #625,733, May 30, 1899.

Bauer, G. A., German Pat. #191,710, Mar. 8, 1907; British Pat. #4385, June 11, 1908; Chem. Abst., Vol. 2, p. 1636, 1908; Chem. Abst., Vol. 3, p. 306, 1909.

Boettger, R., Polytech. Notizbl., Vol. 23, p. 129, 1868; Dingl. Polytech. Jour., Vol. 188, p. 288, 1868.

Boirre, C., British Pat. #28,605, Oct. 26, 1911.

Caine & Thorpe
Chemical Dictionary

Chester, W.
Private Communication

Colbert, W. H. & Morgan, W. L.
U. S. Pat. #2,394,533 Feb. 12, 1946

Cowper-Coles, S. O.
Brit. Pat. #2396 Feb 1, 1910

Diemer, M E.
Jour. American Chem. Soc. Vol. 35, p. 552, 1913

Donau, J.
Monatsch, Vol. 26, p. 525, 1905
Monatsch, Vol. 27, p. 71, 1906

Draper, H.
Smithsonian Contribution To Knowledge
Vol. 14, p. 1856, reprinted in Vol. 34, p. 40, 1904

Eidlitz, L.
Brit. Pat. #893 Apr. 9, 1860

Freund, E. & Deutsch, F.
U. S. Pat. #2,186,452 Jan 9, 1940
Chem. Abst. Vol. 34, p. 3493, 1940

Gardner, I. C. & Case, F. A.
Bureau of Standards, Circular #369, January 1931

Gibson, C. S.
Nature, Vol. 140, p. 279, 583, 1937
Compt. Rend. 17th. Congress Chem. Ind. Paris, Sept.-Oct. p. 877, 1937
Brit. Pat. #497,240 Dec. 15, 1938
Chem. Age, Aug. 20, 1938, p. 137
U. S. Pat. #2,171,086 Aug. 29, 1939
French Pat. #837,178 Feb. 3, 1939
Ind. Eng. Chem. Vol. 31, p. 1186, 1939
Chem. Abst. Vol. 31, p. 1186, 1939
Chem. Abst. Vol. 33, p. 3753, 6789, 1939
Chem. Abst. Vol. 34, p. 73, 1940

Gibson, C. S. & Nield, J.
Gold Mirrors, July 31, 1945

Gmelin's
Chemical Dictionary, 8th. Edit. p. 537, 1936

Guthier, A. & Huber, J.
Zeit. Anorg. Chem. Vol. 85, p. 383, 1914
Chem. Abst. Vol. 11, p. 1928, 1914

Harden, A.
Proc. Chem. Soc. Vol. 15, p. 158, 1899

Hauser, E. A.
Indust. Eng. Chem. Vol. 31, p. 31, 650, 1939
Chem. Abst. Vol. 33, p. 3194, 1939

Heritage, R. J. & Balmer, J. R.
Metallurgia, Vol. 47, p. 171, 1953
Met. Fin. Vol. 51, 75, 1953

Herrmann, F.
German Pat. #147,562 Feb. 5, 1903
German Pat. #178,523 Sept. 5, 1905

Kirk, R. E. & Browne, A. W.
Jour. American Chem. Soc. Vol. 50, p. 337, 1928
Chem. Abst. Vol. 22, p. 1519, 1928

LaHodney, Wm.
U. S. Pat. #1,744,316 Jan. 21, 1930
Chem. Abst. Vol 7, p. 2636, 1913

Lenher, V
Jour. American Chem. Soc. Vol. 35, p. 546, 1913
Chem. Abst. Vol. 7, p. 2363, 1913

Loiseleur, J.
Compt. Rend. Vol. 209, p. 993, 1939
U. S. Pat. #2,278,722 Apr. 7, 1942
Chem. Abst. Vol. 34, p. 6149, 1940
Chem. Abst. Vol. 36, p. 4798, 1942

Mason, R. B.
U. S. Pat. #1,988,012 Jan. 15, 1935
Chem. Abst. Vol. 29, p. 1380, 1935

Mellor's
Chemical Dictionary

Monack, A. J.
Glass Industry, Vol. 28, p. 21, 1947
Chem. Abst. Vol. 41, p. 7691, 7694, 1947

Petitjean, T.
Brit. Pat. #1681 July 24, 1855
U. S. Pat. #15,950 Oct. 21, 1856

Roux, F. A.
U. S. Pat. #1,207,218 Dec. 5, 1916
Chem. Abst. Vol. 11, p. 246, 1917

vonLiebig, J. F.
Brit. Pat. #1255 June 3, 1858
U. S. Pat. #33,721 Nov. 12, 1861
Jour. Franklin Inst. Vol. 56, p. 318, 1856
Ann. Vol. 97, p. 132, 1856

Teotino, U. & Silla, F, Italian Pat. #450,936 Aug. 19, 1949. Chem. Abst. Vol. 45, p. 837, 1951.

Traube, J. & Jacoby, D., Zeit. Anorg. Chem. Vol. 170, p. 85, 1928. Chem. Abst. Vol. 22, p. 2502, 1928.

VonAngerer, E., Wien-Harms, Handbuch Exper. Phys. Vol. 1, p. 375, 1926.

Weyl, W. A., THE GLASS INDUSTRY, Vol. 28, p. 349, 1947.

(Next month the author will discuss lead sulphide films on glass).

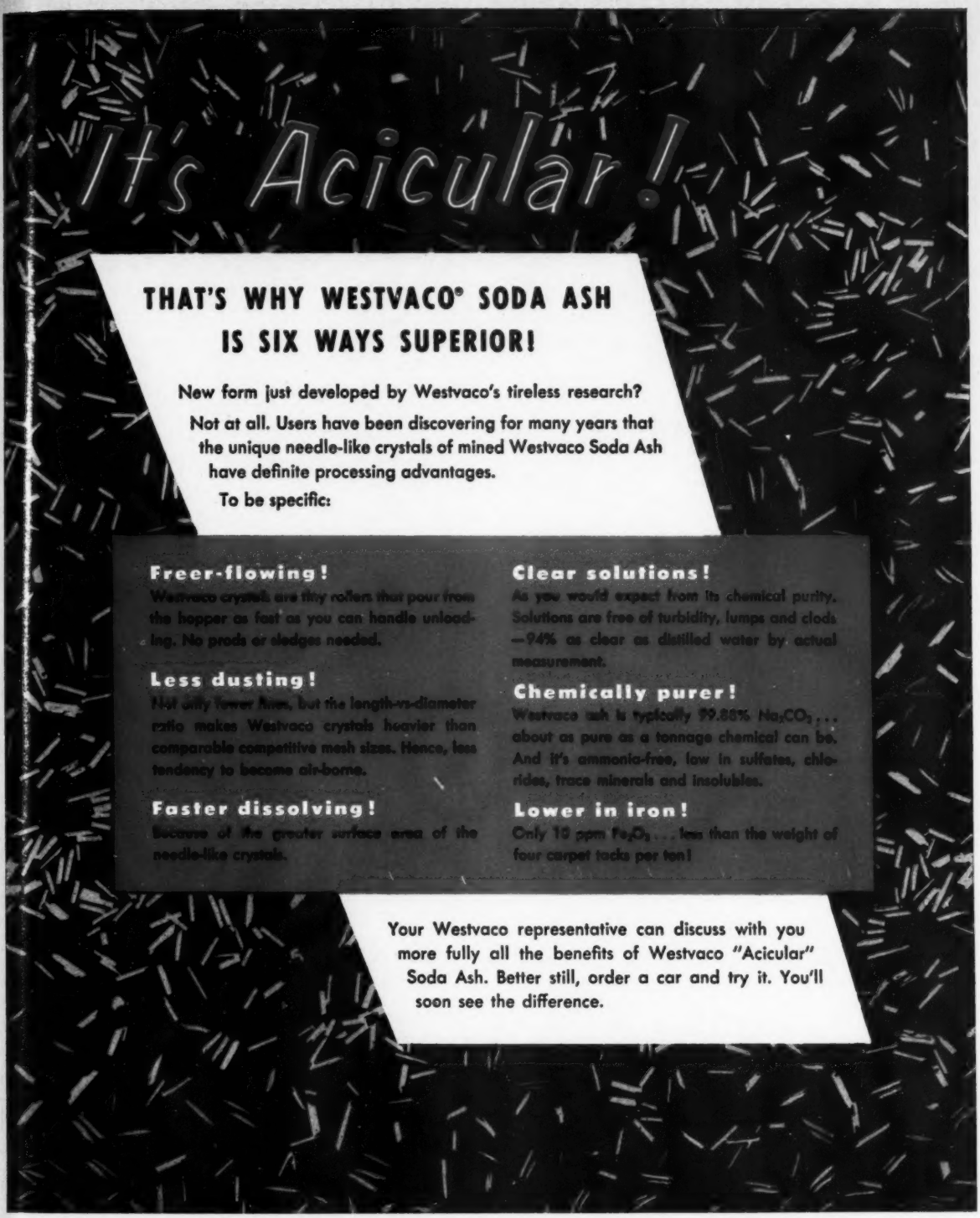
William Chittenden Taylor

(*Continued from page* 297)

paper slip which identified a batch of glass tubing. The foreman knew it was either G8 or B1. He took a sample to Dr. Taylor who felt it carefully, tasted it, and immediately declared it to be B1, to the astonishment of the foreman. Dr. Taylor did not mention that he recognized a slight characteristic tint in the glass.

Dr. Taylor received an honorary doctor of science degree from Alfred University in 1946. He was awarded the Howard N. Potts Medal of the Franklin Institute jointly with Dr. Sullivan in 1928 and in 1940 received the Modern Pioneers of Industry Award of the National Association of Manufacturers.

He was a Fellow of the American Ceramic Society, a member of the American Association for the Advance-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ment of Science, the Society of Glass Technology and the American Chemical Society.

He came from a seafaring family. Much of his early education came from his mother on board ship, and his father, who was one of the last clipper captains. As a youth Dr. Taylor sailed eleven times around The Horn between east coast ports and San Francisco, and he made several trips around the world. He had passed through the grades from fourth to first mate and had become a master mariner.

Drawing on his experience of the sea, he was always keenly interested in the Sea Scouting movement and gave freely of his time to boating activities associated with this program. He also continued his interest in sailing and was a member of the Boothbay Harbor, Maine, Yacht Club.

Dr. Taylor joined the Corning Rotary Club in 1926 and in 1934 was elected its 14th president.

He was an enthusiastic gardener, nursing over the years a compost pile which he applied so successfully that he earned the reputation of being able to make anything grow.

Dr. Taylor served at one time as alderman of the City of Corning, and in Wiscasset, Maine, where he had a summer home, he held office and took an active part in community life.

He was married to Alice C. Pratt on December 29, 1909, at Dorchester, Mass. Mrs. Taylor survives with one daughter, Miss Marion Taylor of Boston, Mass.; one son, Richard L. Taylor of Linwood, N. J.; one granddaughter; and his brother, Joseph L. Taylor of Frankfort, Germany.

Said one of his associates: "His first aim in life was his work and this was so thoroughly and quietly done that its efficiency was overlooked by many who were not in a position to evaluate it. His technical skill can no doubt be replaced, but the man himself will never be replaced. He will always be remembered by those who were fortunate to have had some first-hand knowledge of his contributions."

—Eugene C. Sullivan

Inventions and Inventors

(*Continued from page* 316)

glass here can be such that fining is effected with great rapidity.

As a result of the small dimensions of the fining zone, the heat losses are greatly diminished.

As a result of the localized heating at the surface, and over the whole surface, convection currents are substantially confined to the upper portion of the glass in the fining zone, and the fined glass in the lower portion is not mixed with the unfined glass.

The fining zone *c* is connected with the working zone by a duct of small cross section *e* leading from the bottom of the fining zone to the working zone *f*, whence the glass flows along the channel *g* to the outlet *h*.

There were 18 claims and 30 references cited.

Glass Compositions

Potassium-fluorine glasses. Patent No. 2,840,482. Filed February 27, 1952. Issued June 24, 1958. No sheets of drawings; none reproduced. Assigned to Pennsalt Chemicals Corporation by William J. Knapp and Isadore Mockrin.

This invention relates to novel potassium-fluorine glasses and methods of making the same, and to improved enamel compositions suitable for forming protective and decorative coatings on aluminum and aluminum base metals.

The glass compositions of the present invention, besides containing potassium and silicon from the 45 to 55 per cent potassium fluosilicate, also contain at least two of the oxides, Al_2O_3, B_2O_3, and SiO_2. Though it is generally preferred that some or all of these calculated oxides, Al_2O_3, B_2O_3 and SiO_2 be present, useful glass compositions can still be obtained when any one of these three oxides is omitted, as long as at least two of them are present.

It is preferred, however, that the Al_2O_3, B_2O_3 and additional SiO_2 not be present in the final glass in calculated amounts greater than 36 per cent Al_2O_3, 50 per cent B_2O_3, and 47 per cent additional SiO_2. All percentages are on a weight basis. The calculated fluorine content of these glasses varies from 23 to 29 per cent. The glasses may also contain other ingredients, together with these oxides, as is clearly illustrated by the glasses of the following table. However, it is preferred that the K_2SiF_6, Al_2O_3, SiO_2 and B_2O_3 make up at least 90 per cent of the total glass. Some of the better glasses are listed below.

GLASSES	1	2	3	4	5
K_2SiF_6	45.0	50.0	47.5	45.0	45.0
K_2TiF_6	5.0				
KCl			5.0		
SiO_2	20.0	20.0	19.0	25.0	27.5
Al_2O_3	22.5	17.5	21.4	22.5	17.5
B_2O_3	7.5	7.5	7.1	2.5	5.0
ZrO_2		5.0			
PbF_2				5.0	
BiF_3					5.0
Fusion Temp., °C.*	561	567	547	579	587

* By fusion block method, see Andrews, "Enamels," p. 331, The Twin City Printing Co., Champaign, Illinois, 1935.

There were 9 claims and the following references cited in this patent.

United States Patents

38,286, Cobley, Apr. 28, 1863 and 2,165,554, Kreidl, July 11, 1939.

Foreign Patents

638,710, Germany, 1936; 138,023, Austria, 1934; and 603,623, Great Britain, 1948.

Glass Wool and fiber

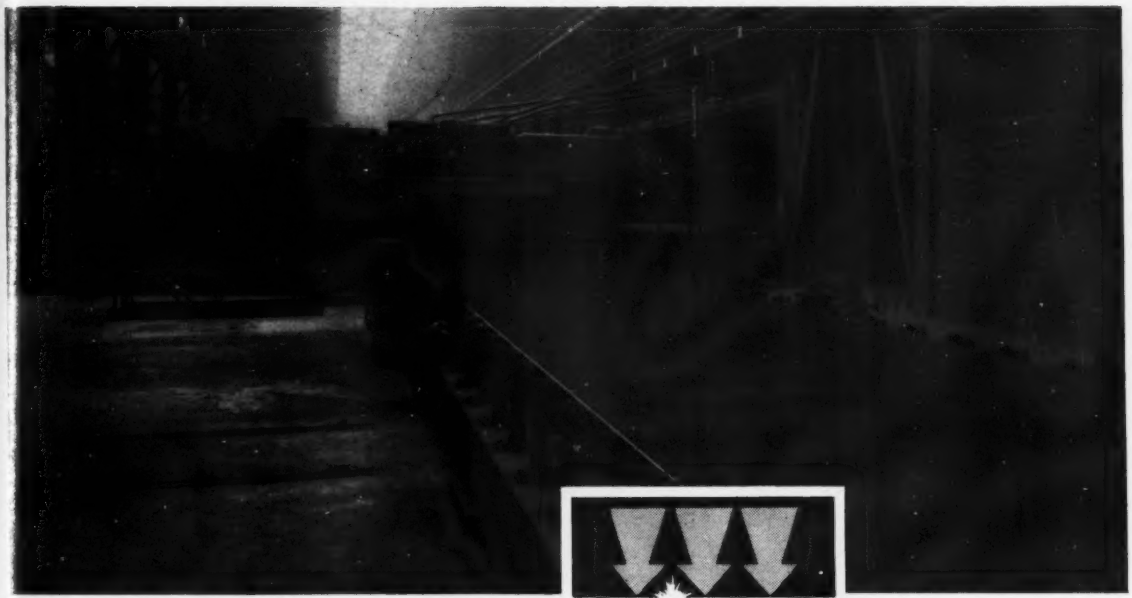
Mineral Wool Depelletizing Apparatus. Patent No. 2,789,694. Filed March 21, 1955. Issued April 23, 1957. One sheet of drawings; none reproduced. Assigned to The Garlock Packing Company, by Leander H. Hills.

This invention relates to apparatus for removing pellets from mineral wool.

The apparatus comprises a hopper of suitable size for receiving a measured charge of mineral wool to be

(*Continued on page* 334)

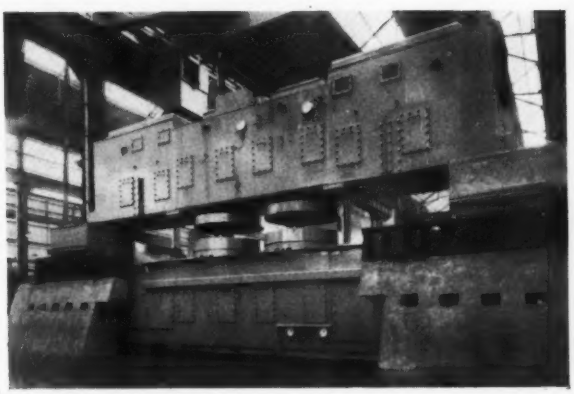
highest efficiency...
greatest precision!



Réalisations RICHARD

DUPLEX GLASS MACHINES - "SAMBRE" TYPE

New apparatus for grinding
and polishing of plate glass
upon both sides simultaneously.
Perfect surface of
unequalled precision.
Completely automatic.



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(*Continued from page* 332)

depelletized, passing it into a conduit wherein an air current, maintained by a blower, entrains the wool as it passes from a deflector at the hopper outlet and carries it into and upwardly in a fan-shaped or upwardly diverging duct, the upper end of the duct opens into a depelletizing chamber defined largely by walls of a cabinet or housing.

The depelletizing chamber is defined by a sharply sloping screen which may be considered as both the bottom and one side of the chamber. The top of said chamber comprises a partially cylindrical, fixed wall and a partially cylindrical, movable wall, or door, pivotally connected to the upper edge of the wall to adapt it to be swung from a closed to an open position. This circulation of the wool continues as long as the door remains closed.

During the circulation of the wool in the chamber, the pellets in the wool are shaken free and fall down upon and through a screen into a drawer or other suitable receptacle for removal. The screen should be of a fineness adapting it to pass the pellets but not the wool.

There was 1 claim, and the following references, cited in this patent.

United States Patents

245,584, Toulmin, Aug. 9, 1881 and 484,202, Holt, Oct. 11, 1892.

Manufacture of foamed latex sponge reinforced with glass fibers. Patent No. 2,809,174. Filed October 26, 1953. Issued October 8, 1957. No drawings. Assigned to United States Rubber Company by Paul Dereniuk.

According to the invention advantages are obtained if the slurry of glass fibers in water containing a cationic surface-active agent is prepared as a three-phase system of water, solids and air having a wet density of 0.2 to 0.8 gram per cc. before being mixed with the latex or the foam. It is possible to utilize a slurry of glass fibers in water containing a non-ionic surface-active agent if it is similarly prepared as a three-phase system of water, solids and air having the same wet density.

Sheet and Plate Glass

Grinding tools used for grinding flat glass and other materials. Figs. 3A and 3B. Patent No. 2,820,334. Filed May 2, 1956. Issued January 21, 1958. Assigned to Societe Anonyme des Manufactures des Glaces et Produits Chimiques de St. Gobain, Chauny & Cirey by Robert Touvay.

The present invention relates to rotary tools, called "runners," used for grinding sheets or plates of glass, or other materials.

It is known that the grinding surface of rotary tools is in the form of an annulus intersected by distributing channels opening into the central aperture of the tool which is surrounded by the annular grinding surface. The channels extend to near the peripheral wall of the tool by which their outer ends are closed.

It has been observed that this evacuation of abrasive, which is pulsatory in nature, might be insufficient so that a suitable circulation of new abrasive might not always be assured for the working surfaces.

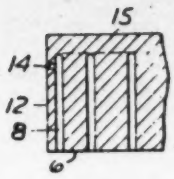


Fig. 3a

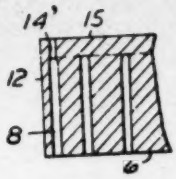


Fig. 3b

As indicated in Figure 3A an aperture *14* is formed in the peripheral wall *12* of the runner, at the base of the distributing channel *8* and near to its closed end. The cross sectional area of the aperture *14* is smaller than the cross section of channel *8* so that a certain predetermined pressure on the abrasive liquid in the channel is maintained and at the same time an evacuation of this liquid outside of the runner is assured in a constant manner during the whole of the rotation of the runner.

The exit area assured by aperture *14* remains constant so long as the wear on the runner has not brought the working plane to reach the level of this aperture. From this moment, the effective evacuation area diminishes.

This latter circumstance cannot occur in the construction shown in Figure 3B where the evacuation aperture *14'* opens outside the runner, not from the peripheral wall *12* of the runner, but on its horizontal top surface *15*, which is not in contact with the glass.

There were 5 claims and the following references cited in this patent.

United States Patents

670,593, Murnane, Mar. 26, 1901 and 2,019,171, Cassity, Oct. 29, 1935.

Foreign Patents

507,816, Belgium, June 13, 1952 and 526,919, Great Britain, Sept. 27, 1940.

Method and apparatus for processing glass. Patent No. 2,831,791. Filed July 29, 1953. Issued April 22, 1958. No sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Daniel T. Downes, Wilkinsburg, and Edward Faustin.

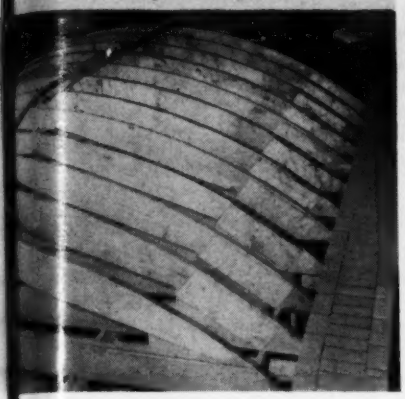
This invention pertains in general to laminated glass and in particular to apparatus for pressing an assembly of bent glass sheets and an intermediate sheet of thermoplastic material to seal the edges thereof, prior to placing the assembly in the autoclave for completion of the laminating process.

The one-piece automobile windshields now being installed are examples of laminated bent glass which requires apparatus of an entirely different design for effectively eliminating the trapped air and for sealing the sheets together prior to placing the assembly in an autoclave. Such bent glass sheets not only have sharp, deep bends at the ends when measured longitudinally of the sheet, but also have a pronounced curve transversely of the sheet both at the center where the longitudinal curve is relatively flat and at the ends.

The present invention provides a preliminary pressing apparatus with a pair of pressing rolls which will follow

(*Continued on page* 336)

Here are shown the wooden arches for supporting the form on which the castable refractory was tamped into place.

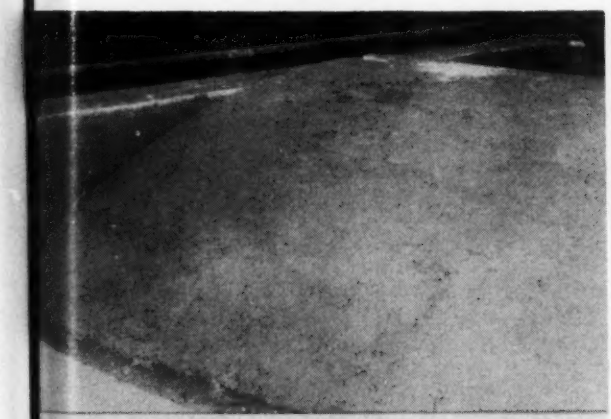


Before applying the castable, forms were greased and covered with waterproof paper, to prevent loss of water and to facilitate removal of the forms. Wooden partitions divide arches lengthwise into four sections for flexibility when heated and cooled.

H-W Extra Strength Castable cuts flue arch costs 25%... gains 4 days' production time

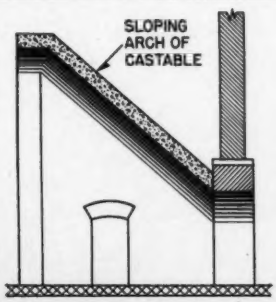
This series of pictures shows the installation of two identical flue arches connecting glass furnace regenerators to stacks.

The H-W Extra Strength Castable was prepared in a concrete mixer. In this illustration it is being placed in one of the four longitudinal segments. Sections 1 and 3 were tamped the first day; sections 2 and 4 the following day.



Exterior view of one of the completed arches. Note the smooth, joint-free structure. Uniform thickness is accurately maintained. Accurate measurements at top of arch showed no rise when heated.

Interior view of arch at stack end. Grand total of all costs, estimated by the glass company, was 75% of previous installation with brick. Of even greater importance was the time saving—at least four days of production. A recent check shows these arches continuing in service after five years.



In addition to horizontal arches, H-W EXTRA STRENGTH CASTABLE is exceedingly useful for the unusually difficult brick construction of sloping arches similar to the one here illustrated.

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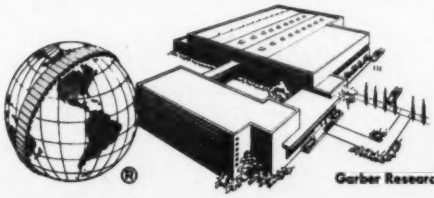

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(*Continued from page* 334)
the contour of a bent glass assembly which rolls are controlled by the weight of the glass assembly in the necessary vertical and tipping movements of the rolls to accomplish their intended purposes.

The flexible pressing rolls during rotation draw the bent glass assembly between the rolls and are capable of revolving, twisting, tipping, deflecting, and moving vertically to conform to the contour of the bent glass assembly.

The apparatus is provided with suitable conveyors for feeding the glass assembly into the rolls and for receiving the assembly after passing through the rolls.

There were 14 claims and the following references cited in this patent.

United States Patents

2,075,726, Kamerer, Mar. 30, 1937; 2,334,651, Schafer, Nov. 16, 1943; 2,628,177, Boicey et al., Feb. 10, 1953; 2,635,973, Swindler, Apr. 21, 1953; and 2,673,168, Pascoe et al., Mar. 23, 1954.

Other References

Faires: *Design of Machine Elements*, published by Macmillan, N. Y. C., 1937, Fig. 289, page 365; Fig. 284, page 357.

Automatic abrasive liquid distributing device for optical lens polishing machines. Patent No. 2,819,569. Filed February 24, 1955. Issued January 14, 1958. No sheets of drawings; none reproduced. Assigned to Etablissements Pierre Angenieux by Pierre Angenieux.

This invention relates to machines for polishing optical lenses, and more particularly to a device for automatically distributing an abrasive liquid in machines of the type comprising a concave part-spherical member and a convex part-spherical member contacting each other, one of these members consisting of the optical surfaces to be polished and the other of the polishing tool proper, both members being imparted an adequate relative movement with respect to each other.

The device comprises a closed-circuit arrangement in which the abrasive liquid is caused to flow with a relatively large output, the relatively small amount of liquid required for treating the common contact surfaces of the co-acting, part-spherical members being taken automatically and intermittently from this circuit and distributed between these co-acting surfaces, the installation being adapted to supply a plurality of polishing machines.

There were 3 claims and the following references.

United States Patents

1,409,888, Taylor, Mar. 14, 1922; 1,513,813, Hill et al., Nov. 4, 1924; 1,619,344, Hill, Mar. 1, 1927; 1,620,021, Hitchcock, Mar. 8, 1927; 1,625,197, Eisenhauer, Apr. 19, 1927; 1,800,743, Morris, April 14, 1931; and 2,069,261, Cassity, Feb. 2, 1937.

Foreign Patents

215,661, Great Britain, May 15, 1924.

Tube and Cane Machines

Means for preventing the darkening of glass tubes by the action of mercury. Patent No. 2,844,035. Filed October 6, 1954. Issued July 22, 1958. No sheets of drawings; none reproduced. Assigned to ....., By Holger Hesse.

In a measuring device including a quantity of mercury in a closed container having first and second portions, only the first of which is exposed for visual observation, the quantity of mercury passing through the apparatus to occupy different levels in the first portion which is exposed for visual observation and thus indicates the value of a quantity to be measured; the interior of said second portion being coated with an adhesive substance selected from the group consisting of glue, resin and rubber, the coating covering at least a part of the container walls along which the mercury passes and being limited to said second portion and the mercury contracting surface of said second portion being tacky.

There was 1 claim cited in this patent.

Apparatus for forming tubular structures in glassware. Patent No. 2,869,286. Filed October 28, 1955. Issued January 20, 1959. No sheets of drawings; none reproduced. Assigned to Jack G. Lubelle (one-third) and Lew C. Silverman (one-third) by Melvin Z. Mullen.

This invention relates to an apparatus for forming tubular structures in glassware such, for example, as cross tubes or fluid passageways in hollow glass stoppers or stopcocks of the kind used in laboratory or chemical apparatus, or glass tubes extending through hollow glass articles such as bottles, for decorative or other purposes.

A glass tube extending through a hollow glass body is formed from glass which is drawn from the surrounding side walls of the original glass article. Instead of relying upon a difference in fluid pressure (e. g., air pressure) to force the softened glass walls inwardly to make the tube, the present invention utilizes plungers producing positive mechanical pressure upon the softened glass walls in the desired places and in the proper directions, although it is within the scope of the invention to utilize fluid pressure differences in conjuncton with and as a supplement to the positive plunger pressures.

There were 9 claims and the following references cited in this patent.

United States Patents

810,474, Doane, Jan. 23, 1906; 1,628,342, Tyson, May 10, 1927; and 1,824,216, Klopp, Sept. 22, 1931; 2,146,572, Hahn et al., Feb. 7, 1939; 2,523,006, Gaskill et al., Sept. 19, 1950; 2,573,429, Geier, Oct. 30, 1951; 2,704,125, Taylor, Mar. 15, 1955; and 2,722,086, Mullen, Nov. 1, 1955.

American Ceramic Society Annual Meeting

(*Continued from page* 300)

Mr. Savant originally became interested in the ceramic field as a result of his first job which happened to be with Bharat Glass Works in Bombay, India. During his three years of employment with the company, he states, he was assigned a wide variety of tasks which exposed him to many facets of glass manufacture. It was at this time that he decided to direct his education toward ceramic engineering. He is a graduate of the University of Calcutta. (*Continued on next page*)

Ross Coffin Purdy Award

This Award, given annually for the most valuable contribution to ceramic technical literature during the past year, was presented to Dr. Arnulf Muan, associate professor in the Department of Metallurgy at Pennsylvania State University. His paper, "Reactions between Iron Oxides and Alumina-Silica Refractories," was published in the August, 1958, issue of the *Journal of the American Ceramic Society*.

John Jeppson Medal

Given in recognition of scientific, technical, or engineering achievements in the ceramic field, the John Jeppson Medal was this year presented to Karl Schwartzwalder, director of research for the AC Spark Plug division of General Motors. He is a past president of the American Ceramic Society and a former chairman and trustee of the White Wares Division.

Fellows of the American Ceramic Society

The following men, 24 in all, were elevated to Fellows of the Society in honor of their work in advancing science and industry.

Adrian G. Allison, Battelle Memorial Institute, Columbus, Ohio.

Arthur J. Blume, Murray Tile Co., Cloverport, Ky.

Charles A. Bradley, Jr., Corning Glass Works, Corning, N. Y.

Edward S. Campbell, Northwestern Glass Co., Seattle, Wash.

Charles S. Cruikshank, Great Lakes Foundry Sand Co., Detroit, Mich.

Edwin M. Dietterle, Ferro Corp., Los Angeles, Calif.

Baird L. Dorsey, Jones & Laughlin Steel Co., Pittsburgh, Pa.

Bernard F. Gentsch, United Clay Mines Corp., Trenton, N. J.

Ralph E. Grim, University of Illinois, Urbana, Ill.

Joseph H. Handwerk, Argonne National Lab., Joliet, Ill.

J. R. Hensler, Bausch & Lomb Optical Co., Rochester 2, N. Y.

Albert R. Lesar, A. P. Green Fire Brick Co., Mexico, Mo.

Louis R. McCreight, General Electric Co., Philadelphia, Pa.

Frederick R. Matson, Pennsylvania State University, State College, Pa.

Walter S. Mayer, Mayer China Co., Beaver Falls, Pa.

Grant E. Miller, Ferro Corp., Cleveland, Ohio.

Lowell H. Milligan, Norton Co., Worcester, Mass.

Elburt F. Osborn, Pennsylvania State University, University Park, Pa.

Errol B. Shand, Corning Glass Works, Corning, N. Y.

Edward J. Smoke, Rutgers, The State University School of Ceramics, New Brunswick, N. J.

Norman H. Stolte, Harshaw Chemical Co., Cleveland, Ohio.

J. K. Teague, Jr., Owens-Illinois Technical Center, Toledo, Ohio.

Donald V. Van Gordon, Metal & Thermit Corp., Rahway, N. J.

E. Joseph Weiss, University of Texas, Austin, Texas.

How well do you know your glass?

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- ☐ 2. Arabic enameled vase
- ☐ 3. Syrian ewer
- ☐ 4. Hellenic funeral urn

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Water in the Glass Structure

(*Continued from page* 303)

slightly. This is thought to be due to a nitrate band according to Florence, because according to Schaefer and Bormuth[14] nitrates also possess absorption bands in this region.

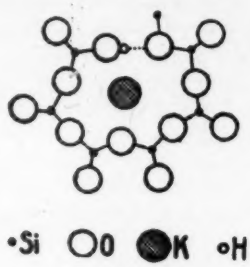

Fig. 7

Schematic presentation of the arrangement of ions in a lime-silicate glass with OH groups.

On the other hand, on examining the spectra of the carbonates in the extensive series-experiments of Hunt, Wisherd and Bonham[15] and Miller and Wilkins[16], only one strong band is found at 7.0 microns in the near-infrared. The latter authors have used only small quantities of material for measurements. From Schaefer's work one can calculate the molar decade extinction coefficient for carbonates

$$\epsilon = \frac{\log \frac{1}{D}}{c\,d}$$

where D = *transmittance*
c = *concentration in moles /liter*
d = *thickness in cm*

In the case of $CaCO_3$ the transmittance at 0.07 mm thickness was only about 10 per cent at 3.4 and 3.9 microns. From these values one obtains $\epsilon = 5.3$.

From the gas-analytical data of Table 1 0.01 mole/liter is obtained for the concentration of carbonate in glasses (calculated value). Using this value the transmittance for a 1 mm. thick layer is about 99 per cent. Thus the strong band at 3.6 - 3.7 microns cannot be due to carbonate content in the glasses. This could also be verified experimentally. In this earlier work it was found that the water content of glasses prepared from a batch containing soda crystals is higher than that prepared from dry soda[17].

Because of this another glass was melted under similar conditions (2 hours at 1450°C in an electric furnace; 74 weight per cent SiO_2, 16 per cent Na_2O and 10 per cent CaO). The batch was first thoroughly dried and enough D_2O was added to correspond to $Na_2CO_3 . 10D_2O$. The infrared transmittance of this melt is compared with the earlier melts in Fig. 5. If the band at 3.6 to 3.7 microns were due to carbonate content the intensity of this band should be identical to that of glass prepared from $Na_2CO_3 . 10H_2O$ batch.

This is not the case. The glass prepared from D_2O—containing batch has a much greater transmittance. The small absorption which still remains is due to water

trapped in the quartz grains and traces of moisture from the furnace atmosphere. The OD bands due to D_2O are not observed since they occur at longer wavelengths and are obscured by other bands.

From these calculations and experiments it is found that the broad band at 3.6 to 3.7 microns is due to OH groups. Strong hydrogen bonding exists, and the O - O distance must be very small. At 3.65 microns the O - O distance in Lord and Merrifield's diagram "Dependency of wavelength shift on O - O distance" is 2.66 A[11]. This value is in excellent agreement with the O - O distance of 2.65 A obtained by X-ray technique by Warren and Biscoe[18]. The position of the OH-band at 3.6 to 3.7 microns is not unusual because Lord and Merrifield have obtained OH bands at values as high as 4.1 microns (for example $NaHCO_3$).

Thus one does not need to assume a decrease in water content in high alkali-containing glasses.

Experiment 2

The glasses have a high absorption at 5 microns and it is therefore necessary to use very thin layers in this region. Fig. 6 shows infrared curves for two thin sections of fused silica and a soda-lime glass. Additional measurements in this region of alkali glasses give similar curves. The position of the bands at around 5.5 microns are more composition-dependent than those at 6.2 microns. The latter band cannot be caused by liquid water but is due to Si-O vibrations as has been shown by Drummond[19] in comparison with quartz.

If one examines in the above-mentioned series of experiments[15, 16] the absorption curve of a few compounds with water of crystallization one can recognize in addition to a band at 2.9 microns an additional band at 6.25 microns. The intensity of the latter is generally less. In order to observe the band in these glasses thicker glass samples must be used. As a result, however, the Si-O vibrations in the 5 micron region cause such a strong absorption that it becomes impossible to observe the weak water band. Thus these experiments do not enable one to distinguish between molecular water or OH groups.

The discovery of the dependency of OH-bands on O - O distance leads to the question of how the water is held in the glass. Since the time Warren published his X-ray results on silica glass[20] it has been assumed that the structure of fused silica is similar to that of cristobalite. *In cristobalite the structure is open, and the holes are still relatively large.* Flörke[21] has shown that the holes are large enough to accommodate *spheres having a radius of 1.7 A.* There is one hole per Si atom; the distance from the midpoint of one hole to that of a neighboring hole is about 3.1 A. In fused silica one can assume that the structure is also open; it differs, however, in that the size of the holes varies due to the random arrangement of the silica tetrahedra. Furthermore, because of the lower density of fused silica the total volume of the holes is somewhat larger.

The numerical data for the diameter of a water molecule varies from 2.0 to 2.6 A, the most frequently mentioned value being 2.2 A. Thus the water molecule is small enough to fit in the holes of fused silica.

The molar decadic extinction coefficient of H_2O vapor,

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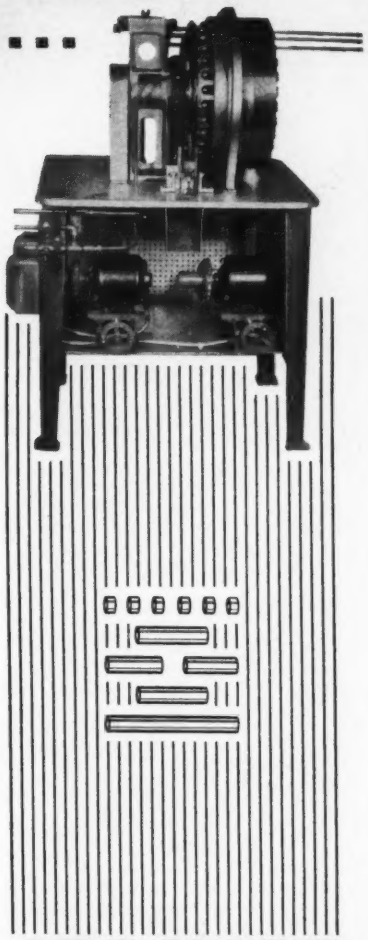

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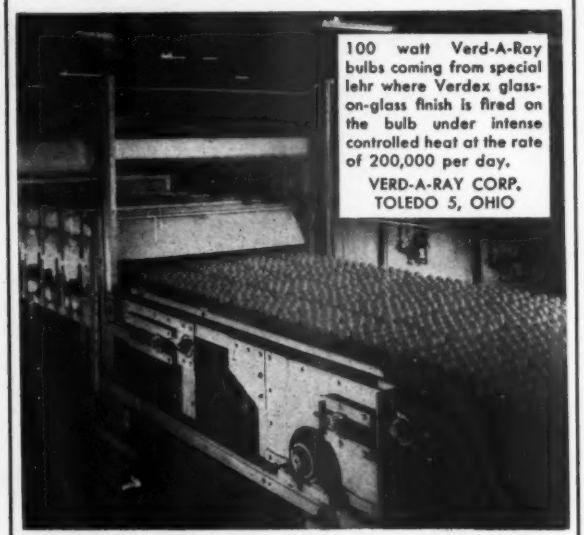
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H_2O in CCl_4, liquid water and ice for OH-valency vibrations, according to Fox and Martin[22], are 3, 38, 55 and 120. In other words, the coefficients increase with increasing association with water. An available sample of fused silica had a transmittance of 80 per cent at 2.75 microns for 1 mm thickness. Assuming that 100 grams of fused silica contain 70 cm_3 H_2O (from gas analysis data for borosilicate glasses of Table 1) one obtains $\epsilon = 14$. This value fits nicely in the above group of extinction coefficients, and for this reason it is very probable that fused silica contains molecular water. This view is based on the following explanation of experimental results. As was previously pointed out an accurate statement regarding the way water is held in the glass cannot yet be made; however the same reasoning holds for OH groups.

The OH band for fused silica is at 2.75 microns. The H_2O molecule fits readily in the holes of the glass. The distance to the oxygen ions of the network is great so that only weak H bonds can occur. Any alkali added to the fused silica will enter the holes. A sufficient number of holes are available for water when the alkali content is low, and consequently no shift in OH band is observed.

As the alkali content increases, more and more holes become occupied by alkali. Only small holes are available for water; that is, the O-O distance of the hydrogen bonds decreases and as a result the OH-band is shifted towards larger wavelengths. This phenomenon can be expected sooner with large cations than with small cations, which is in agreement with the experiment.

The work by Norton[23] and by Newkirk and Tooley[24] on permeability of glasses is in agreement with the above reasoning. They found that H_2, He, D and Ne permeability of fused silica can be readily measured, but Ar, O_2 and N_2 permeability cannot be observed. The atomic radii of these gases is 1.95, 2.5, 2.55, 2.4, 3.2, 3.15 and 3.4 A for the gases, in the order mentioned. The helium permeability decreases with increasing alkali content.

The OH band at 2.75 to 2.95 microns in glasses is satisfactorily explained by assuming that the holes in the glass are occupied by molecular water or OH groups. In addition to this type of water in the glass structure there exists still another type which is characterized by a broad band at 3.6 to 3.7 microns. This band is unique in that its position is not altered by composition and its intensity on one hand increases with increasing alkali content and, on the other hand, with increasing basicity of the alkali ions. The strong hydrogen bonding with an O-O distance of 2.66 A can be explained only if one assumes the presence of OH groups. A simple explanation of how the water is held in the glass results if one assumes that the hydrogen ion is attached to single-bonded oxygen ions and that hydrogen bonding takes place between it and its neighboring oxygen ion, as shown schematically in Fig. 7. The alkali ion is in immediate vicinity of OH groups. In addition to the influence of size of alkali ion this representation also shows why the stronger basic potassium ion favors this type of water bonding.

This investigation has raised a large number of additional questions, and work is in progress to attempt to answer them.

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The findings show that it is mainly water which affects the absorption characteristics of glasses in the region up to 4 microns. The heating and cooling characteristics of glasses are closely connected with this since this region lies nearest to the maxim of infrared radiation.

In the last few years it has been shown that theoretical results have a practical application. It can be assumed that the above findings will also find practical uses.

The author extends his appreciation to Dr. A. Dietzel for his valuable and stimulating discussion.

Summary

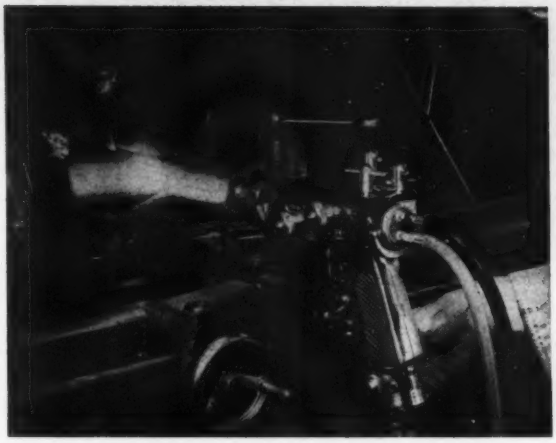
Water is held in two different ways in glass.

1. The OH-band at 2.75 to about 2.95 microns is probably due to molecular H_2O—possibly also OH-groups—held in the holes of the glass structure.

2. The broad band at 3.6 to 3.7 microns, which until now has been wrongly assumed to be due to carbonate, is due to OH-groups whose hydrogen ion is bonded to a singly bonded (non-bridging) oxygen ion and a neighboring oxygen atom. The O-O distance of the two oxygens involved in this type of bonding is 2.66 A.

REFERENCES

1. H. Salmang and A. Becker. Gases in glass. Glastechn. Ber. (1928), 520-37; *6* (1929), 625-34; *7* (1930), 241-44.
2. R. H. Dalton. Gases in glass. J. Amer. Ceram. Soc., *16* (1933) 425-32.
3. R. H. Dalton. Extraction and analysis of gases from glass. J. Amer. Chem. Soc. *57* (1935), 2150-53.
4. C. Hahner, G. Q. Voight and A. N. Finn. Gases in some optical and other glasses. J. Res. Nat. Bur. Stand. *19* (1937), 95-103
5. A. J. Harrison. Water content and infrared transmission of simple glasses. J. Amer. Ceram. Soc. *30* (1947) 362-66.
6. W. Lyon and E. L. Kinsey. Infrared absorption spectra of the water molecule in crystals. Phys. Rev. *61* (1942), 482-89.
7. J. M. Florence, F. W. Glaze, C. H. Hahner and R. Stair. Transmission of near-infrared energy by binary glasses. J. Amer. Ceram. Soc. *31* (1948), 328-3.
8. J. M. Florence, Ch. C. Allhouse, F. W. Glaze and C. H. Hahner. Absorption of near-infrared energy by certain glasses. J. Res. Nat. Bur. Stand. *45* (1950) 121-28.
9. J. M. Florence, F. W. Glaze and M. H. Black. Transmission of near-infrared energy by some two- and three- component glasses. J Res. Nat. Bur. Stand., *50* (1953), 187-96.
10. R. E. Rundle and M. Parasol. O-H stretching frequencies in very short and possibly symmetrical hydrogen bonds. J. Chem. Physics, *20* (1952), 1487-88.
11. R. C. Lord and R. E. Merrifield. Strong hydrogen bonds in crystals. J. Chem. Physics, *21* (1953), 166-67.
12. O. Glemser and E. Hartert. Investigation of bonding of water in crystalline salt. Naturwiss. *42* (1955), 534.
13. C. Schaefer, C. Bormuth and F. Matossi. The infrared absorption spectrum of carbonate. Z. Physik *39* (1926), 648-59.
14. C. Schaefer and C. Bormuth. The infrared absorption spectrum of sodium nitrate. Z. Physik, *62* (1930) 508-09.
15. J. M. Hunt, M. P. Wisherd and L. C. Bonham. Infrared absorption spectra of minerals and other inorganic compounds. Analyt. Chem. *22* (1950), 1478-97.
16. F. A. Miller and Ch. H. Wilkins. Infrared spectra and characteristic frequencies of inorganic ions. Analyt. Chem., *24* (1952) 1253-94.
17. H. Scholze and A. Dietzel. Investigation of the water content in glasses by means of infrared absorption in the region 1-5 microns. Glastechn. Ber. *28* (1955), 375-80.
18. B. E. Warren and J. Biscoe. Fourier analysis of X-ray patterns of soda-silica-glass. J. Amer. Ceram. Soc., *21* (1938) 259-65.
19. D. G. Drummond The infrared absorption spectra of quartz and fused silica from 1 to 7.5 μ II. Experimental results. Proc. Roy. Soc. London A, *153* (1936) 328-39.
20. B. E. Warren, H. Krutter and O. Morningstar. Fourier analysis of X-ray patterns of vitreous silica and B_2O_3. J. Amer. Ceram. Soc., *19* (1936), 202-06.
21. O. W. Florke. The influence of alkali ions on the crystallization of SiO_2. Z. Geologie, *3* (1954), 71-73.
22. J. J. Fox and A. E. Martin. Investigation of infrared spectra (2.5-7.5μ). Absorption of water. Proc. Roy. Soc. London A. *174* (1940), 234-62.
23. F. J. Norton. Helium diffusion through glass, J. Amer. Ceram. Soc. *36* (1953) 90-96.
24. T. F. Newkirk and F. V. Tooley. Study of effect of cation concentration and size on Helium permeability of alkali-silica glasses. J. Amer. Ceram. Soc. *32* (1949) 272-78.



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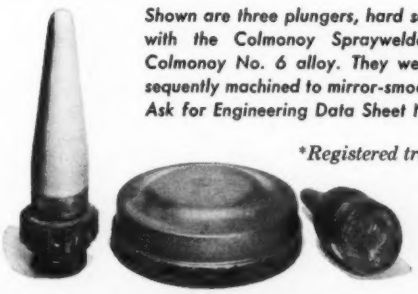

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